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AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*Geology of the Shonkin Sag and Palisade Butte Laccoliths in the Highwood Mountains of Montana;* by W. H. WEED and L. V. PIRSSON.*

Introductory.—On the southeast side of the Highwood Mountains, the open treeless plains country which stretches away in all directions from the foot of the broken volcanic hills of tuffs and lava, has its monotony interrupted by a tract of broken and sharply accidented character. Although separated from the rest of the mountain group by certain geological features not elsewhere seen and by its outlying position, it is nevertheless an integral portion of the Highwood eruptive area since it belongs to the same geologic period of eruptive activity and is merely a prolongation of the eruptive masses in this direction, separated, like the rest of the mountains, from the other igneous groups of central Montana by wide stretches of sedimentary rocks which are undisturbed by such intrusions.

This area is terminated and its accidented character accentuated by the deep trench-like valley which Arrow River has scored in the plain and where, in the deeply carved band of badlands which decorates its margin, are revealed the parti-colored strata of the level-lying Cretaceous.

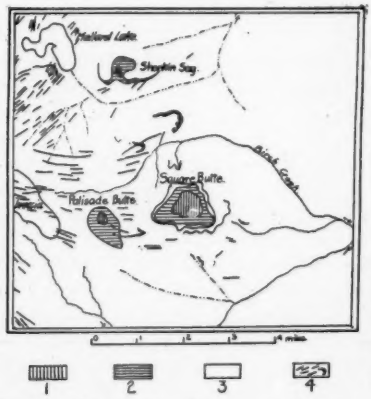
Topographically and scenically, this region is characterized by the dark frowning masses of Square and Palisade Buttes, which form such prominent landmarks across the level horizon and weary miles of the vast open prairies, and by the debouchement of the shallow valley of the Shonkin Sag, elsewhere described, into that of the Arrow River; while minor features

* By permission of the Director of the U. S. Geological Survey.

are the deep erosion of the margins of the valleys into bad-lands, of those of the igneous masses into fantastic rock piles, and the many heavy, black dike walls which cross the open stretches or form buttresses along the slopes.

A petrographical description of the sodalite-syenite of Square Butte by Lindgren and Melville* is the first publication relating to the geology of this part of the Highwood Mts. area which has come to our attention. Its geology and petrography have been fully described by the writers in a later paper,† and the geology of the area as mapped by the authors has been published in the Fort Benton Folio of the Geologic Atlas of the United States accompanied by text briefly describing the geology by Mr. Weed.

Geologically the area differs from that of the rest of the Highwoods in that it is one of intrusion devoid of extrusive igneous masses. The evidence at hand does not show that here the magmas ever attained the surface and produced volcanic outbreaks; if such occurred, the extrusive material has long since been swept away by erosion and the facts point rather to the view that this has not occurred.



Syenite. Shonkinite. Cretaceous. Dikes and sheets.

FIG. 1. Map of Laccoliths.

The igneous masses are divided into the Square Butte, Palisade Butte, and the Shonkin Sag laccoliths, and the dikes and intrusive sheets, as seen on the map figure 1.

Although topographically and in size it is the least of the laccoliths and, at first sight, of the least importance, we shall commence with an account of the Shonkin Sag laccolith for the reason that geologically it is the most important and supplies the key to certain features which they all possess in common. Moreover, it is in several features and in the character of its dissection by erosion one of the most perfect laccoliths that has been described, and its internal structure is such as to render it an occurrence of great importance in theoretic petrology.

* This Journal, vol. xlv, 1893, p. 289.
† Bull. Geol. Soc. of America, vol. vi, 1895, pp. 389–422.

The Shonkin Sag Laccolith.

Where the Shonkin Sag valley debouches into that of Arrow River it has a wide and open character with walls of sloping debris or deeply carved Cretaceous strata. It is cut by several small streams of excellent water which burst out as springs under the base of Square Butte and find their way into Arrow River. Through the middle of the level valley floor wander the alkaline waters of Flat Creek with feeble, sluggish current, dried away in summer to standing pools. It is crossed by the stage road from Benton to Lewistown, and on the open flat stand the buildings of the relay stage station.

Proceeding from here up the valley in a westerly direction, at first the heavy mass of Square Butte above and to the left dominates the scene, and in the sandstones upon which it rests are seen intruded sheets of black basaltic rock. About a mile or so to the west appears on the left an intrusive mass of dark colored shonkinite which rises in a cliff wall over a hundred feet in height, the talus from whose foot slopes down to the valley floor. This wall is not more than a few hundred yards in length and the intrusion seems to be clearly a separate one from that of Square Butte and the Shonkin Sag laccolith. Where its contact is seen, it cuts abruptly through the light colored sandstones. It has a quite distinct columnar structure and although evidently not a typical or symmetrical laccolith, so far as one can judge from the exposures seen, it is clearly a small intrusion of laccolithic character.

On the opposite, the northern and eastern, side of the valley several dikes of basaltic rock are seen cutting the sandstone wall; then an intruded sheet appears in the sediments above the talus slopes. This persists, and following it a turn in the valley reveals the front wall face of the Shonkin Sag laccolith. From the opposite side of the valley, whose width is here sufficient, an excellent view of it is obtained, and it is seen as a long columnar cliff stretching for a distance of about one mile, and with a quite even and regular face, interrupted at about the middle by a deep canyon-like gulch which cuts down through the whole thickness of the cliff at this point. The columnar structure is quite pronounced, the polygonal columns having a diameter of a couple of feet or more, and in length, that is in height, they were estimated to be over one hundred feet, which measures the thickness of the laccolith along the cliff front. Below, all along the front, the laccolith is seen resting on the light brown Cretaceous sandstones which form the floor upon which it lies. They are quite horizontal and the regular even level of this floor is very noticeable. From the foot of the cliff a great talus descends down to the

valley floor; it is not an even regular sheet of detritus but is carved down at rather regular intervals by rain-washed gulches and raised at the points between by a more abundant supply of materials, so that it presents the appearance of a rude series of intersecting half cones or steep fans resting against the cliff wall of the valley. The surface of these talus cones is generally grassed over, giving a rather smooth appearance, but they are elsewhere covered with large blocks of rock from the

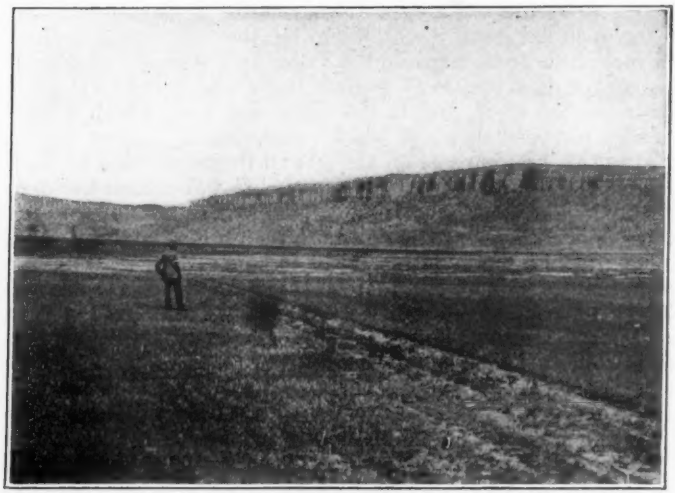


FIG. 2. Cliff wall of Shonkin Sag laccolith. Dissecting gulch to left over standing figure.

great columns of the cliff above, which have broken down and whose pieces have rolled down the slopes. At the apices of the cones the material reaches nearly or up to the foot of the columns, and the sandstones of the laccolith floor are in places nearly concealed, but in the intervening gulches a considerable thickness of them is seen. On top of the laccolith are seen resting the Cretaceous sandstones into which it is intruded in horizontal, unbroken position. Their thickness is variable as from each end of the cliff-wall it gradually diminishes until about the middle, where the laccolith is cut by the intersecting gulch, they disappear, leaving, especially on the eastern side, a portion of the top of the laccolith bared. On the opposite side of the gulch, however, a considerable thickness of them is seen resting on top of the columns of igneous rock.

Ends of the Laccolith Wall.—From what has been said above, it is clear that this cliff wall is the cross section of a flat mass intruded into and lying between the beds of sandstone, its laccolithic character being seen only at the outer borders. No real distinction can be drawn which will separate laccoliths from intrusive sheets: the most typical laccolith can be regarded as a very short, thick, domed sheet, and conversely, an intrusive sheet can be regarded as a very flat, thin laccolith. In our work in the mountain areas of central Montana, we have observed all degrees of transition between the two. Nevertheless, in the typical laccolith we presuppose a certain, quick up-arching of the strata which we do not observe in the typical intrusive sheet.

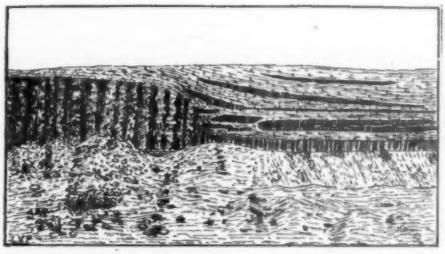


FIG. 3. Sketch of east end of laccolith showing relations of strata and intruded sheets.

This character is well shown by the Shonkin laccolith at the eastern end. The main body of the laccolith rounds quickly down at a pretty sharp angle until it becomes only the thin intrusive sheet, previously mentioned, not more than ten feet in thickness, which on the same horizon extends a great distance out into the sandstones. Besides this main lower fringing sheet there are two or three lesser ones which do not extend far and quickly die away in the sedimentary beds, and in addition, at the spring of the demi-arch of sandstones, where there must have been a certain relief of pressure, there are small subordinate intruded masses of igneous material of lenticular character and somewhat cusp-shaped cross section. These relations are shown in fig. 3 from a careful outline drawing made on the spot, and are also seen in the photograph, fig. 2. All of these details are as clearly seen on the great cliff wall of the valley as in the diagrammatic section, the contrast of the black intruded rock masses with the light-colored sandstones being of the most pronounced kind. It is noticeable to see how the beds have adjusted themselves to the upward bend without much breaking or rupturing.

At the other end the relations are less clear, the valley wall has been broken down and eroded somewhat so that there is not the same vertical cut, but the exposures are quite sufficient to show that the structure is less typical, the beds having yielded to some extent by rupturing. The laccolith, however, frays out in thin, fringing sheets, and the basal sheet, to which it thins down, has the same thickness and character as on the other side and may be traced, always at the same level horizon, among the sandstones several miles up the valley. The persistency of these basal sheets or indeed, more correctly, of the one thin sheet of which the laccolith is itself a greatly thickened portion, is quite remarkable.

The Laccolith Rock.—The rock composing the outer fringing sheets is dark colored of dense texture spotted with crystals of a black augite and round white spots of an altered leucite; it may be called a leucite basalt. The lower 12 to 15 feet of the great columns of the main body of the laccolith are also composed of this rock, which then passes into a fully granular one of granitic texture consisting of augite, olivine, biotite and orthoclase, the shonkinite described in our paper on Square Butte previously referred to. At the top the columns pass into the porphyritic leucite basalt again, and as this contact modification has a somewhat different color from the dark shonkinite, each of the vast columns, at a distance, has a quite distinct capital and base of a different color from the main body of the shaft.

Interior of the Laccolith.

It has been mentioned that the central portion of the laccolith wall has been broken by an intersecting stream gorge which has cut down through it and into the underlying sandstones upon which the laccolith rests. A small stream of clear water issues out of the gorge and nourishes some vegetation in its bottom, whose greenness is in grateful contrast to the somber rock masses rising on all sides and to the arid valley of Flat Creek. At the very entrance to the gorge and picturesquely shaded by a grove of tall cottonwood trees stand the buildings of the Wilson ranch looking down the slope into the Flat Creek valley or Shonkin Sag, as seen in fig. 4. Following up the stream, its bottom gradually rises above the sandstones until it is in the igneous rock and at the same time it branches out into tributary gulches, so that in this way the whole interior of the laccolith is thoroughly dissected and laid bare for inspection and study.

In the rising floor of the gulch, one soon comes to the contact of the igneous rock and the sandstones on which it rests,

and there is here afforded a good opportunity to observe the effect of the contact metamorphism. The fissile, platy sandstones at the contact, are changed to a dense, flinty rock of a blue color, which is generally but a few inches in thickness and the total effect about a foot; in places, however, the change to the blue rock, the maximum effect, may be as much as two feet. Thus the actual amount of metamorphism produced in the sediments is very limited. The igneous rock at the con-

FIG. 4. Mouth of dissecting gulch. Shonkinite resting on sandstones on the right.

tact is very dense and dark, filled with augite and altered leucite phenocrysts; it is similar to that described in the outer columns above. It maintains this character for a height of about fifteen feet and then passes into an evenly granular, coarse-grained shonkinite. This has a columnar parting which, as one approaches nearer the center, is less evident than in the outer cliff wall. The branching drainages now lose their perpendicular canyon-like character and widen out into V forms with broader spurs between them, in places grassed over but often showing wide expanses of naked rock. In other places they are covered with heapings of morainal drift whose rounded pebbles are composed in part of what appears to be rocks of Bearpaw types and in part of Canadian. It is thus not local but general in character, and thus possesses a peculiar significance, which will be adverted to again in another place. It is the most southern point reached by the drift in this place, and marks the limit in this direction of the terminal moraine.

Always ascending, the shonkinite is found to have a thickness of about seventy-five feet, when it suddenly passes into a rock of quite different character. So far as the exposures show there does not appear to be any contact between the two, but the shonkinite quite suddenly, in a little distance, passes into the new type. This is a much lighter colored rock of a coarser grain, so coarse, in fact, as to have quite a pegmatitic appearance. It is composed of large augites, many of them one to two inches long, often radiating from a common center in such a manner as to form stars, and equally long but slender foils of biotite, filled in between with white feldspars or feldspathic material. This rock was always found in so weathered and crumbled a condition that no good fresh specimens of it could be obtained. In thickness, this layer or zone is about fifteen feet and it passes above into a white syenite of medium grain, specked with augite crystals. This has a rather thin, horizontal, platy parting, by which it splits and weathers into piles of plates. Seen in the bright light of a clear, sunny day, the contrast with the dark shonkinite makes the one seem white, the other black, especially when they are seen in large masses. In hand specimens, the contrast, though very strong, is not so pronounced.

FIG. 5. Erosion monoliths in interior of laccolith.

This syenite resists weathering much better than the crumbly, transition rock mentioned above and has, therefore, conditioned the formation of curious and fantastic rock piles along the line of the outcrop. They commonly take the form of a mushroom or stool in which the outspreading top is formed of the syenite, while the stem is composed of the transition rock. They are illustrated in fig. 5 from a field sketch. These are often fifteen feet or so in height and their mode of formation is much like that of rock tables standing on an ice foot on the surface of a glacier or the breccia hoodoos of the Yellowstone Park. They are somewhat different and smaller than the monoliths of the hoodoo zone around the base of Square Butte, which have been formed in a somewhat similar way. Seen in rows along the hillslopes at the outcrop of the transition rock, they present a weird and curious effect, suggesting crude architectural efforts of some primitive race. In other places the transition rock weathers back along the outcrop into shallow caves, the floor of shonkinite, the roof of syenite, the entrance

marked by thick pillars of the transition rock. This is merely an earlier stage of the development of the isolated mushroom-like masses, and one phase of it is shown in fig. 6.

The thickness of the platy white syenite is about 25 to 30 feet and above, always ascending, it passes in narrow limits into the same coarse, crumbly, transition rock as that below it. Here on top, however, this is but about five feet in thickness and it then passes into a coarse shonkinite like that below; this in about five feet begins to be denser and blacker, and in about five feet more it becomes a porphyritic rock spotted with augites and altered leucites, the same leucite basalt as at the very bottom.

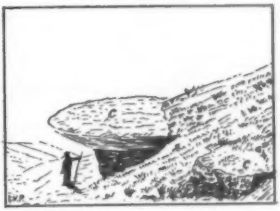


FIG. 6. Early stage of erosion monolith.

We are now on the very top of the laccolith; an elevated plateau devoid of vegetation save for a sparse growth of grass. On all sides, except on the cliff looking down into the Shonkin Sag, it rolls gently down towards the sediments showing a marked turtle-back form and its center is cut into by the descending gulches which merge into the dissecting gorge. Except around this basin it is covered with the overlying sediments, but here the top of the igneous rock is exposed. In one place the cover was found to be cracked and filled with a dike of much altered basic rock.

Cause of the Dissection.

In the foregoing description there has been given somewhat fully the actual facts to be observed in the field, and there now remains the interpretation of them. From what is stated elsewhere in the chapter on the Shonkin Sag and from the presence and character of the morainal drift, it is evident that during the glacial period the continental ice sheet in this region pushed its way as far south as the lower slopes and foot-hills of the Highwood Mountains. In its advance the Missouri River was driven southward and forced to flow around the foot of the ice front. In doing so it excavated the valley of the Shonkin Sag and thus sawed down and through the outer circumference of the laccolith as a knife might cut down through a cake. It is possible and even probable that the river deepened and cut out an already existent smaller valley, entirely removing the outer section of the laccolith. The position of the intersecting tributary was also previously determined, and the ice moved over the already eroded surface of

the laccolith. Evidences of scouring and polishing were not observed on those parts of the laccolith surface which were crossed, but it is probable that they may exist. The dense hard basalt of the contact variety was noted as scratched and striated boulders in the drift. At the close of the glacial period the river retreated to its present position, and since then erosion has deepened and extended the dissection. The relative position of the former Missouri valley, the laccolith, and the dissecting stream are shown in the adjoining fig. 7, which represents them in a diagrammatic ground plan. In fig. 8 is given a stereogram of the laccolith in which the various points mentioned are shown in a diagrammatic way. The dotted surface at the top represents in a general manner the area bared by erosion.

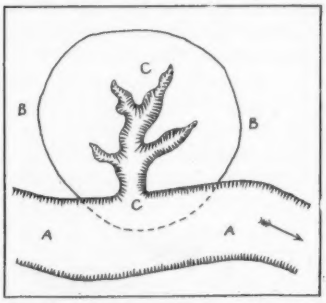


FIG. 7. AA, former Missouri valley. BB, laccolith. CC, intersecting tributary.

Internal Structure.

From the description which has been given, it is clear that the outer portion of the laccolith is different from the interior

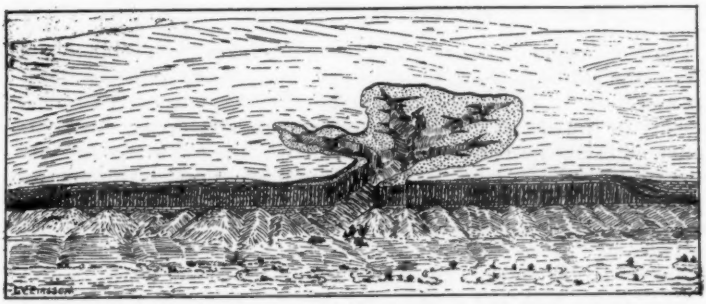


FIG. 8. Stereogram of Shonkin Sag laccolith.

in the character and types of rocks composing it. These may be concisely summed up in the following section, which may be regarded as approximately correct.

Sections of Laccolith.

	Center feet.	Outer wall feet.
Leucite basalt porphyry	5	10–15
Dense shonkinite	5	-----
Shonkinite	5–6	-----
Transition rock	3	-----
Syenite	25–30	-----
Transition rock	15	-----
Shonkinite	60–75	75
Leucite basalt porphyry	15	15
Total (approx.)	140	100

From these data we can now construct a cross section of the laccolith which will have the appearance shown in fig. 9.

FIG. 9. Cross section of Shonkin Sag laccolith.

In this figure the cross section is in its natural proportion as regards the relation of the vertical and horizontal scales, and this shows the sheet-like or flattened character of the laccolith. The transition rock and the syenite are included in the uncolored portion of the section; their vertical thickness is known, but their horizontal extension is from necessity largely conjectural, since we have the distance of its extension from the center in only one direction towards the outer cliff wall side, as revealed in the dissecting gulch.

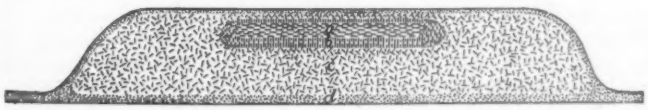


FIG. 10. *a*, Syenite; *b*, transition rock; *c*, shonkinite; *d*, leucite basalt porphyry. Vertical scale six times the horizontal.

Fig. 10 is simply an enlargement of the preceding diagram in order to exhibit better the relation of the parts. The vertical scale is six times that of the horizontal in order to bring the diagram within practical limits. This does not, of course, affect the relative ratios of thickness of the different layers to one another.

Our interpretation of the facts previously described then, is, that if one were to take the cross section of fig. 10 and revolve it upon a perpendicular drawn through the middle point, the resulting figure of revolution which would be generated would exhibit our conception of the laccolith and the structural relation of its interior parts. It is true this would cause the laccolith to become a true circle in ground plan, and the successive shells and syenite kernels to be also circular in ground plan or projection on a horizontal map surface, and to have a common center—and we do not know that this is exactly the case; the laccolith may be more or less ellipsoidal or irregular in outline and so also the interior shells and the kernels; they may not have exactly common centers nor be everywhere of the same thickness, and this is very probably the case; nevertheless, these are mere details and we believe of little importance in comparison with the idea that the figure would express the generally circular, concentrically zonal arrangement of the parts.

While the discussion of the facts presented and the conclusions drawn from them in their special relation to recent theories in the field of petrologic research would carry us too far for the purposes of this paper, it will be well to point out here some of the important bearings they have in this respect.

In the first place, it appears clear to us that the structural relations of the different parts of the laccolith to each other are due to causes which have operated in the laccolith itself. We conceive that the body of the magma forming the laccolith must have been injected as a whole, in a homogeneous condition, and that rearrangement and formation of the various parts followed within the mass itself. The occurrence of ball-like masses in the upper crust of the laccolith seems to show that the filling took place with considerable rapidity. We believe that after injection of the homogeneous magma, the first stages of cooling and crystallization against the outer envelope of sedimentary rocks was relatively more rapid than that affecting the inner portion, and resulted in producing the outer porphyritic shell, the zone of endomorphic contact metamorphism. In the meantime, and as time went on, there was a gradual withdrawal and concentration of lighter feldspathic material by some process of differentiation, to the inner upper portion of the mass, with a relative enrichment of an outer zone in lime, iron, and magnesia. This is most marked in the case of the white, inner syenite, and naturally less so in the transition rock.

After the process had finished or perhaps while it was still going on, crystallization and solidification were advancing from

without inwardly, and finally the laccolith was formed as we now find it.

On the other hand, we do not believe that the laccolith was produced by successive injections of magmas of different chemical composition which were injected into those already injected and solidified, splitting them in the process. The significant, orderly and regular arrangement of the different parts in concentric zones, the lack of contact phenomena between them, their gradation into one another from the most basic on the outside to the most acid on the inside, and the chemical relationships of the different types all seem to us to clearly forbid such a supposition, to say nothing of the mechanical difficulties involved. And also the recurrence elsewhere in this district of the same rock types with similar arrangement as at Square Butte, has a positive bearing on this point and is another strong, if not conclusive argument against such a theory.

It also appears to us that the theory, where acid, feldspathic, intrusive masses are formed with basic border zones rich in lime, iron, and magnesia, that this is due to absorption of such material by the fluid magma from the surrounding rocks is not applicable in this case, however, it may be elsewhere. The reasons for this may be divided into three heads.

First. From the regular and orderly arrangement of the parts, it is evident that such absorption could not have taken place at lower horizons with subsequent injection of the homogeneous magma into its present position. If melting and absorption of the sediments took place, it did so in the place where the mass now is. But in this case it is clear that the magma must have had the composition of the inner, highly alkaline syenite. An inspection of the section drawn on the natural scale will at once show that, to produce the great body of shonkinite from the syenite, there must have been melted up and absorbed a vast body of surrounding rock, an effect inconceivably too great for any body of injected molten magma to perform. And in this case how should we explain the thin fringing sheets, homogeneous throughout, having nearly the same composition as the shonkinite, and which run out for such great distances among the unchanged sandstones.

Second. The theory demands that lime, iron, and magnesia should be the elements absorbed, but the laccolith lies surrounded by Cretaceous sandstones, composed chiefly of quartz with some feldspar. Indeed, in the sedimentary formations of this portion of Montana described by us in numerous memoirs,* we know of no series of beds which, melted up,

* Geology of the Castle Mountains Mining District, Bull. 139, U. S. Geol. Surv.; Geology of the Judith Mountains, 18th Ann. Rep., U. S. Geol. Surv., Part III, p. 437; Geology of the Little Belt Mountains, 20th Ann. Rep., U. S. Geol. Survey, Part III, p. 257.

would produce the desired result; we should have to imagine selective melting and absorption, a quite incredible idea.

Moreover this is shown by a consideration of the chemical character of the two main types of igneous rocks. An analysis of the shonkinite has been made for us by Dr. W. F. Hillebrand in the laboratory of the U. S. Geological Survey and is given below under No. 1. Dr. Hillebrand has also made a partial analysis of the syenite, the character of the material not warranting more extended work, and this is given under No. 2.

Analyses.

	I.	II.
SiO_2	47·88	50·00
Al_2O_3	12·10	19·36 (+TiO_2+P_2O_5)
Fe_2O_3	3·53	3·87
FeO	4·80	2·67
MgO	8·64	2·18
CaO	9·35	4·96
Na_2O	2·94	3·63
K_2O	5·61	8·52
H_2O+110°	1·52	3·53 (Ign.)
H_2O−110°	·70	·46
CO_2	·12	----
TiO_2	·77	with Al_2O_3
ZrO_2	·03	----
P_2O_5	1·11	with Al_2O_3
V_2O_3	·04	----
SO_3	none	----
Cl	tr.	----
F	·05	----
S	·025	----
Cr_2O_3	·035	----
NiO	tr.	----
MnO	·15	----
BaO	·46	----
SrO	·13	----
Li_2O	none	----
	99·99	99·18

The analysis of the syenite shows 12 per cent of alkalis and in order to change this to the composition of the shonkinite an enormous amount of material would have to be added. The same may be said with regard to the alumina. It will be noticed, however, that the silica remains practically the same. The argument is the same as that which we have already adduced for Castle Mountain* and at Yogo Peak in the Little Belt Mts.†

* Bull. U. S. Geological Survey, No. 139, 1896, p. 133.
† 20th Ann. Rep. U. S. Geol. Surv., 1900, Part 3, p. 577.

Third. There is not the slightest evidence of melting and absorption of the beds in place, in fact, as we have previously described, the amount of contact metamorphism is extremely limited. Moreover, an inspection of the cliff wall fronting the Shonkin Sag, shows that the beds on top of the laccolith are the same as those which elsewhere rest on its basal beds: they have simply been lifted by the intrusion of igneous material and there is nothing lacking in the sedimentary series, a fact which at once disproves the idea of melting and absorption.

We may thus with the utmost confidence dismiss these two hypotheses, that the arrangement of the rock types is due either to successive injections or to the absorption of sedimentary material by a molten fluid and return to our original proposition, that it has been produced by processes which have taken place within the laccolith itself after it had been injected as a homogenous body of magma.

What these processes may have been will be discussed later in a work on the petrology of the region, but in concluding this description of the geology of the Shonkin Sag laccolith we desire to again remark, that we believe it furnishes one of the best and most conclusive examples of the differentiation of igneous rocks which has yet been described, and we regret that it is not in a more accessible locality for study by other geologists.

Palisade Butte.

By reference to the map, fig. 1, accompanying this paper, it will be seen that Palisade Butte is situated somewhat less than a couple of miles west of Square Butte. It stands isolated upon the open, slightly rolling plains country, and though somewhat dwarfed by the nearness of its greater companion to the east, it forms, like Square Butte, a prominent landmark for long distances across the open prairies. It rises some eight hundred feet above the plain and its outline seen against the sky resembles the weathered stump of some gigantic colossal tree.

On closer inspection its salient features are easily seen. On all sides a long talus slope in great part covered with soil and grass but broken here and there by low outcrops and masses of rock leads up with increasing gradient from the plain to the bare, tall cliffs of naked, massive rock which compose the main mass of the butte. Above these cliffs there are again steep slopes interrupted anew by cliffs.

These great walls are remarkable for the very regular and beautiful columnar structure of the rock, the hexagonal columns being on an average about eighteen inches in diameter

though often greater, divided by regular crossjoints. They extend the whole height of the exposures in which they occur and thus attain a length of 100 to 150 feet in places, but it is evident that originally they must have extended through the whole of this portion of the igneous mass, as shown in the Shonkin Sag laccolith, and therefore may have been several hundred feet in length. It is, of course, by the breaking away of these columns that the vertical cliffs have been formed. At a distance on the plain the butte appears faced by a series of colossal pillars or palisades, and from this appearance it has received its name. It strongly recalls "Mateo Tepee" or the "Bear Lodge Butte" on the west side of the Black Hills.

The rock composing the columnar portion of the butte and the outcrops in the talus is of shonkinite of a somewhat firmer texture and perhaps more feldspathic character than that of Square Butte. On all exposed surfaces it weathers to a very dark color, giving the cliffs a sombre and gloomy character.

In several places the line of cliffs is cut by deep and narrow gulches descending through them, up which one can easily clamber and attain the grassy slopes and shoulders above them, and thus by continuing reach the summit. These grassy slopes are varied here and there by groves and clumps of small pines.

The butte is crowned at the top by a large mass of a light-colored rock of a platy, laminated character. This is an augite syenite much like that already described. It weathers with a much lighter color than the shonkinite on account of the preponderance of the feldspar over the augite, and the contrast between the two, while not so pronounced as at Square Butte, is still a striking one.

The mass of syenite, which has a considerable thickness, is roughly wedge-shaped in form, with a cliff of some height toward the south and a slope toward the north. On the former side, the rock with its platy, horizontal parting is clearly seen to be resting on the massive, columnar shonkinite, but towards the north the relations are less clear because in this direction it slopes down in talus masses and in fact, on this side the butte, to a great degree, loses its precipitous character and slopes sharply down toward the plain, with the broken down rock masses intermingling.

Differentiation.—In the characteristics of the rock composing it, there is to be seen the same differentiation as that found in Square Butte and the Shonkin Sag laccolith, only not so sharply expressed. In the low outcrops of rock in places which rise through the talus slopes and are furthest from the butte, the shonkinite composing them is very rich in augite and therefore dark and basic, like that of Square Butte. As

one approaches the butte there in an increase in the feldspathic components, and the rock of the columnar cliffs is perceptibly different from that of the lower outcrops. In the syenite of the platy mass on top this difference is, of course, much more marked; the rock is not so strikingly leucocratic as the syenites of Square Butte and the Shonkin Sag laccolith, but is still a syenite.

Thus the same order holds as in the other laccoliths, a basic outer and lower mass, above a more feldspathic upper, inner portion, and there has been, therefore, the same kind of differentiation as in the other laccoliths, only more gradually expressed.

Laccolithic Character.—From what has been said we infer that Palisade Butte represents the remains of a laccolith formerly of greater size. We are led to this conclusion by its position, structures, and associations.

The three laccoliths form a transitional group; the Shonkin Sag is the flattest and also the lowest and therefore the one most protected from erosion. Its top, in fact, is just beginning to emerge, and its laccolithic character would not be so evident if it were not for the trenching in it by the former river action which has given such good cross sections. Square Butte stands much higher and has been exposed to much greater denudation; its cover, save in small areas around the base, has been stripped off and a considerable part of the igneous rock removed. Palisade Butte, standing at the same level as Square Butte, has suffered from the same amount of erosive agencies, but being smaller in size the relative effect has been greater and the cover has entirely disappeared, and a large part of the laccolith, so that around it the floor is exposed and only the central portion of the mass remains.

U. S. Geological Survey, Washington, D. C., and Yale University,
New Haven, Conn., April, 1901.

ART. II.—*On the Manganese Ore Deposits of the Queluz (Lafayette) District, Minas Geraes, Brazil;* by ORVILLE A. DERBY.

IN a communication entitled "The Manganese Ores of Brazil," published in the Journal of the Iron and Steel Institute for the current year (1900), Mr. Herbert K. Scott gives a very interesting account of two ore districts in the state of Minas Geraes that within the last few years have sprung into considerable prominence on account of the abundance and high quality of their ores. These two districts, though adjacent, differ widely in geological characters and in the mode of origin of their ores. The Miguel Burnier-Ouro Preto district, which is more particularly described by Mr. Scott, is constituted by a series of quartzites and schists in which hematitic quartz-schists (itabirites) are a prominent feature, the manganese ore occurring in intimate association with these iron schists and with limestone. The geological conditions are therefore similar to those described by Vogt in his work *Salten og Ranen* for certain Norwegian deposits of associated iron and manganese ores that have almost certainly been derived through leaching from iron- and manganese-bearing carbonates. The details given by Mr. Scott are very conclusive in support of this view of the mode of origin, which I have briefly discussed in a note appended to his paper.

In the closely adjacent Queluz* district, on the contrary, the ore bodies occur in association with granitic and gneissic rocks and there is a complete absence of the calcareous and ferruginous beds that accompany the ore in the other district. The mining and prospecting operations thus far effected have, on account of questions of transportation, been limited to a zone 10 to 20 kilometers wide on each side of the railroad. In the zone thus defined the outcrops of ore are so numerous and large as to indicate an extremely extensive and widespread mineralization of an area that is doubtless much larger than has thus far been recognized. The existing maps of the region are so defective that no positive correlation of the different outcrops can be made, but there are strong indications of the existence of at least three distinct ore belts. These are:

1st. A western belt, marked by the two active mines of

* The name Lafayette given in Mr. Scott's paper was given to the railway station in the border of the town of Queluz in order to avoid confusion with another place of the same name in the same railway system. In common parlance the name Lafayette has come into general use for the whole district, but in the administrative division of the state Queluz is still retained as the name of the town and of the municipal district of which it is the center.

Piquiry and São Gonçalo, situated some 3 or 4 kilometers apart on the same ridge, with a number of known intermediate outcrops and probably prolonged southward by others that have been prospected but not worked,

2d. An eastern belt, marked at the extremes, so far as known, by the Morro da Mina (Mine Hill) and Agua Limpa (Clear Water) deposits; and

3d. A central belt, represented by the abandoned Barroso workings close to the railroad a few kilometers south of the town.

At all of the localities above mentioned perfectly sound granite occurs within a few hundred meters of the ore bodies and at Piquiry the wall or walls are constituted by a residual clay resulting from the complete decomposition *in situ* of a typical granitic rock that gives an abundant and characteristic residue of sharp-edged zircons. At São Gonçalo, where only the foot wall is exposed to view, this and some intercallated layers near it are of completely decomposed schists whose original character will be discussed farther on. At Barroso both foot and hanging wall are of decomposed schists that are suspected to have been originally amphibolic, while at Agua Limpa a sound amphibolic schist of peculiar character occurs within a few meters of the ore body. At Morro da Mina, aside from dubious decomposed schists apparently similar to those at São Gonçalo, a peculiar residual clay occurs that will be discussed below. A peculiar feature is the occurrence of well-defined layers of graphitic schist in the ore of Agua Limpa, Morro da Mina and São Gonçalo, while at all of the localities parts of the ore body are more or less graphitic.

The Piquiry ore body presents the appearance of a mass of secondary material, or gossan, resulting from the alteration of a vertical dike or vein, some ten or dozen meters wide. The margins are sharply cut against a tough clay which is undoubtedly decomposed granite, presumably identical with the sound granite occurring a few hundred meters distant from the mine. In appearance both foot and hanging wall are presented, but Mr. Scott thinks that the opening is on an elbow of the ore body, so that in reality only one wall is seen. The ore is a hard spongy black oxide apparently consisting for the most part of psilomelane but with an admixture of other oxides that frequently occur in beautiful crystallizations in the spongy cavities. No cargo analyses are at hand, but Mr. Scott gives for a sample of ore prepared for shipment: manganese (metallic) 51·40 per cent, iron 2·00 per cent, siliceous residue 5·02 per cent, phosphorus 0·13 per cent.

In the midst of the merchantable ore occur inconstant bands and patches of hard siliceous material with the appearance of a

quartzite, but which on examination proves to be composed almost exclusively of a finely granular mass of ashy white manganese garnet. A complete series of alteration-phases between perfectly typical garnet rock and merchantable ore can be readily selected, and there can be no doubt that the latter results from the decay and leaching of the former.

In part from the ore body itself, in part from the dump heap of rejected material, the following phases of the garnet rock were obtained.

1st. A very fine-grained, compact and finely jointed rock of bluish gray color with partings lined with asbestus. Under the microscope the rock is seen to be composed almost exclusively of closely appressed idiomorphic grains of white garnet showing a clear border but with the center highly charged with a fine black opaque powder that appears to be graphite. In the somewhat rare interspaces between the garnet grains and molded upon them is a glassy white anisotropic mineral generally altered to a mass of asbestiform fibers which, so far as its form, optical properties and cleavages can be made out, is a member of the amphibole group. A qualitative test on a small amount of material, largely asbestiform, separated with heavy liquids shows the presence of silica, lime, magnesia, iron, manganese and alumina, the latter in scarcely more than traces, thus confirming the identification of the mineral as an alumina-free amphibole. The only accessories that could be detected in the section are apatite in rare grains and the above mentioned inclusions in the garnet, the reference of which to graphite is apparently confirmed by a distinct reaction for carbonic acid after fusion with nitre and by the presence of free graphite in other similar rocks from the same ore body. An analysis of this rock kindly made by Dr. G. Florence gave:

SiO_2	38·47
Al_2O_3	21·07
Fe_2O_3	7·38
MnO	27·90
CaO	4·70
	99·52

A second specimen of the same general type but not jointed is largely oxidized and stained at the margins and in patches with manganese oxide and has the amphibolic mineral stained brown while the apatite is much more abundant.

2d. A dark brown rock heavily charged with manganese oxide and too friable to permit the preparation of microscopic sections is evidently of the same type as the second specimen above mentioned but more completely decomposed and much

more heavily charged with graphite. The very abundant residue obtained by washing, or by treatment with acid, is in great part of a dirty white color, the garnet grains being discolored by a closely adherent graphitic powder. The amphibolic mineral, apparently more abundant than in No. I, appears in the residues in rudely prismatic forms but is too heavily stained with manganese oxide to permit of a satisfactory determination. No apatite could be detected in the residue, but the acid solution from the rock gave a distinct reaction for phosphoric acid.

3d. A milky white rock which under the microscope is seen to be composed of about equal parts of garnet and quartz, the latter being abundantly threaded with delicate transparent needles of a white asbestiform mineral. The garnet is for the most part larger and better crystallized than in the specimen above described and has a decided yellow tinge. The quartz in a fine mosaic about the garnet grains and in minute refilled joints is almost certainly secondary, filling the place of some mineral that has disappeared. The asbestus (?) needles, in part free, in part included in the quartz, are undoubtedly secondary but not, as in the case above described, formed without migration by the transformation in place of some preëxisting mineral. The only accessory, embedded in the garnet as well as in the quartz and thus probably of primary origin, is a transparent red mineral in minute grains and hexagonal flakes that give strong reactions for both titanium and manganese. The crystallographical, optical and chemical characters of this mineral, so far as they can be made out, agree with those of pyrophanite.

The above observations indicate that the original rock from which this ore body was derived was essentially a manganese garnet rock containing sporadically (and perhaps in segregated masses) an amphibole mineral, apatite, a titanium mineral and presumably an easily decomposable silicate that has entirely disappeared. Graphite is also distributed capriciously throughout the mass, but, as will be shown below, this is perhaps not an original or essential element. The predominant quantity of merchantable ore of high grade shows that by far the greater part of the mass must have been an almost absolutely pure manganese garnet rock from which silica and alumina have been leached out. Since in the process of oxidation iron oxide would almost certainly have remained and have been concentrated with that of manganese, the original rock (and especially the garnet) must have been notably free from this element, which in the ore analyses is in smaller proportions than in the rock sample above analyzed. It is worthy of note that no free iron

oxide, in the form of magnetite, ilmenite or hematite, could be detected as an original element in the sections or residues.

At São Gonçalo the main ore body, composed exclusively of hard secondary material similar in appearance and composition to that of Piquiry, has the appearance of a heavy intercallated bed with an inclination of 30–40° in a decomposed schistose rock. Sound granite occurs a few hundred meters away, but none was seen in immediate contact with the ore. The principal working near the top of a high hill exposes about three meters of the foot wall, consisting of banded clay of predominant red color with white streaks, which on a carefully scraped surface shows a characteristic gneissic structure with indications of small included fragments, or segregations, differing somewhat in texture and color from the body of the rock. On washing, this clay gives a very abundant argillaceous slime, leaving a residue of tolerably abundant white mica (bleached biotite?) with a very moderate amount of quartz and in the heavy portion rare grains of transparent red (secondary?) hematite and tourmaline. Next to the ore body the clay for the space of about 20 centimeters is lighter colored with white and yellow streaks, and this shows very distinctly an augen-gneiss structure. Its residue does not differ materially from that of the underlying reddish clay except that the micaceous portion has more the appearance of secondary sericite.

From the above observations it is tolerably evident that the foot wall at São Gonçalo was a somewhat micaceous gneiss poor in quartz and without characteristic clastic or granitic accessories, that is to say, it was most probably a sheared basic eruptive presumably of dioritic or gabbroitic type.

At the base of the ore body comes a layer about 30 centimeters thick of quartz rock charged with manganese oxide and with the appearance of shattered vein quartz. This give a moderate residue of garnet without other recognizable accessories.

Above the quartzose layer and separating it from the heavy mass of secondary oxide that constitutes the ore body proper, comes a layer about 40 centimeters thick of a banded yellowish clay with tolerably distinct traces of original feldspathic and micaceous elements giving a well-defined gneissic structure. This gives on sliming a residue of secondary (?) mica and earthy grains of manganese oxide.

Higher up in the ore body is another clay layer from 2 to 3 meters thick which on a scraped surface shows a granitoid aspect, with small scattered patches of earthy manganese and iron oxides that appear to occupy the place of some original manganese-bearing bisilicate element. This also gives a very abundant argillaceous slime with a residue of granular kaolin,

secondary (?) mica and, aside from the earthy oxides, a few rare grains of tolerably large and well-formed zircons. This clay body apparently represents an unsheared eruptive rock, possibly of gabbroitic type.

Still another clay horse some 2 meters thick is gneissic in structure with white kaolinitic and greenish and yellowish micaceous (?) elements and nodular masses of clay charged with manganese and iron oxides. The residue after sliming consists of secondary (?) mica without quartz, and heavy dirty white earthy grains with occasional inclusions of rutile that are almost certainly alteration products of ilmenite. Associated with this layer is a thin one, a few centimeters thick, of a pulverulent clay heavily charged with graphite.

With the exception of the above mentioned quartzose layer (or sahlband), which apparently must be considered as an integral part of the ore body and which by its quartz and garnet contents establishes a relation with the original type of the Piquiry ore mass, the mineral at São Gonçalo is so completely altered by secondary processes as to give no clue regarding its original character and origin. The included horses of clayey matter may, *a priori*, be either inclusions of country rock, segregated masses of the original rock of the ore body itself, or intrusive dikes. The hypothesis may be ventured that the gneissoid layer without manganese and with traces of original ilmenite is of the first character, that the gneissoid layer above the quartzose one and with traces of manganese oxide is of the second, while the granitoid body with traces of manganese oxide and with zircon may be a mass of the same character that has escaped shearing, though it is more probably an intrusive dike.

The ore of the main opening is almost exclusively a hard stony, spongy psilomelane like that of Piquiry but presenting more distinct evidences of shear structure. A prospecting analysis by Mr. Scott gave metallic manganese 49·10 per cent, siliceous residue 6·34 per cent, and phosphorus 0·126 per cent. Lower down on the hillside another opening has been made which affords in part a hard secondary ore of the same character as the above, in part an ore of earthy aspect that was at first considered to be of doubtful character but which on analysis proves to be good merchantable stuff. This evidently represents an altered schistose (sheared) manganese-bearing rock in which the resulting oxide has not, to any considerable extent, migrated or been recrystallized but has apparently become somewhat hydrated, since a rough test gives about 6 per cent of water. Its appearance is that of a decomposed argillaceous or calcareous schist profusely pitted with minute rounded cavities that are frequently lined with a fine white crust of secondary silica that, on dissolving the oxide, present the appearance

of pseudomorphs of microscopic garnets. Another locality, to be discussed below, proves that this interpretation is correct and that the pitting of the rock is due to the disappearance of included garnets. Other specimens from the same opening, in which the structure above described is obscured by secondary manganese oxide, give a residue with some sound garnet, with a minute quantity of ilmenite and, on ignition with nitre, a tolerably abundant reaction for graphite.

The Morro da Mina, situated some 6 to 8 kilometers to the northeastward of the town, is a high hill covered quite uniformly with outcropping, or loose, ore and thus presenting the most extensive ore deposit yet known in the district. As, however, this ore is more siliceous than the present high requirements of the market admits, very little has been done in the way of development except in the loose superficial material that gives little insight into the structure of the ore body, but fortunately an old abandoned mining tunnel, apparently driven by some deluded gold prospector, gives a good section of a considerable portion of the mass and below the zone of surface action. As at Piquiry and São Gonçalo, granite occurs in the immediate vicinity of the hill but none was seen in close contact with the ore body. Prospecting operations in the neighborhood show that the ore continues for a considerable distance both northward and southward from the hill, and there are strong indications that in the latter direction a more or less continuous line of outcrops connect this locality with that of Agua Limpa, some ten or dozen kilometers distant.

The above mentioned mining tunnel, which unfortunately could only be examined by the insufficient lighting of matches, extends for about 25 meters in very hard somewhat sheared manganese ore and terminates in soft unsheared clay that evidently represents some massive rock decomposed *in situ*. An assay sample taken by an experienced prospector at every two meters shows that the mass is tolerably uniform in structure and composition and that, except in comparatively insignificant patches, the rock is perfectly fresh. This sample is understood to have given on analysis about 40 per cent of metallic manganese, thus corresponding very closely with the analysis given below of a picked specimen, if, as is presumable, the metallic contents was only determined in the soluble portion, the abundant residue being set down as quartz without further examination. This ore body has the appearance of a vertically sheared dike, or intercalated bed of which one side is free, forming the steep slope of the hill, while on the other side comes the above mentioned clay mass that separates it from another smaller and parallel ore body that outcrops on the top of the hill at a distance of some dozens of meters.

In the specimens obtained from this tunnel the altered patches present the earthy pitted appearance of the above described ore from São Gonçalo and like that give, on treatment with acid, a residue of microscopic garnet, skeletons of secondary silica in the form of garnet and a moderate amount of exceedingly fine black sand giving a strong titanium reaction and that is apparently ilmenite with a slight admixture of transparent red grains without defined form that appear to be rutile. The perfectly sound rock has a hardness between 6 and 7 and a steely luster, but under the lens is seen to be minutely mottled with white points corresponding to the pitting of the decomposed portions. Occasional patches of oriented sheen appear to be cleavage surfaces of large prismatic crystals. Treated with hydrochloric acid, even in considerable lumps, the black portion of the rock is readily and completely dissolved, leaving a considerable residue of white garnet with a slight amount of flocculent silica, ilmenite and rutile (?). Under the microscope the rock is seen to consist of minute isolated grains of garnet embedded in a much more abundant groundmass of manganese oxide of uniform steely luster, except in a narrow zone around each garnet grain where it is coal black and apparently softer. This black zone apparently comes from a beginning of alteration in the garnet, though it may also be due to an incipient hydratation of the manganese oxide of the groundmass. In any case, the rock is essentially a mixture of a hard prismatic, cleavable manganese oxide with a manganese garnet, both being primary elements. An analysis kindly made by Dr. Florence gave:

Residue insoluble in hydrochloric acid	20·78
SiO_2	0·77
Fe_2O_3	5·79
$NiO + CoO$	0·30
MnO	8·54
MnO_2	57·38
P_2O_5	0·08
CaO	0·49
MgO	0·20
H_2O	3·91
	98·24

The deficiency in this analysis is perhaps due in part to the presence of alkalies that were not determined. The manganese oxides calculated as metal and oxygen and reduced to 100 give: Mn. 65·06 per cent, O 34·94 per cent, which corresponds quite closely with the composition of polianite (Mn. 61·1 per cent, O 36·9 per cent), and in view of the physical properties,

so far as they can be made out, it is probable that the rock consists essentially of polianite and spessartine with small amounts of some lime and magnesia silicates, apatite and possibly ilmenite, though a portion of the water is doubtless combined with the manganese, which is in part visibly altered, and the iron may also be, in part, combined with the manganese oxide. The presence of a small proportion of nickel and cobalt is an interesting feature.

The clay in which the tunnel terminates shows no structural features except scattered patches of soft earthy manganese and iron oxides suggestive of segregations of original bisilicates in an essentially feldspathic rock. The slime obtained by washing consists largely of minute micaceous flakes, and the residue of a small amount of minute quartz grains with heavier dirty white earthy grains that give a titanium reaction and are probably leucoxene representing original ilmenite. A specimen taken close to the contact with the ore gives also a small amount of well-formed brown tourmalines, but this does not appear to be generally distributed throughout the clay mass. From the above characteristics it seems almost certain that this clay represents the decomposition product of an original massive eruptive rock that was predominantly feldspathic but with segregations of a manganese-bearing bisilicate element and with ilmenite as the only accessory. If, as seems most plausible, the small residue of quartz be regarded as secondary, the original rock was probably a gabbro or some closely related type.

At the point of the hill and apparently in prolongation of the smaller dike-like outcrop above mentioned as occurring at the top, mining operations had been commenced, in part in loose secondary ore, in part in ore *in situ*. The latter has an impure earthy appearance like that above described from São Gonçalo and such as might be expected to result from the alteration of the hard garnetiferous ore of the tunnel and of the said dike-like ore body. The siliceous residue is understood to run from 16 to 20 per cent and the contents in metallic manganese from 37 per cent to 45 per cent. A small pit showed two ore bodies of this type *in situ*, each being about three meters thick, and separated by a foliated layer of granular quartz rock about one meter thick. This quartzose layer resembles closely the itacolumite of the Ouro Preto region, but, unlike it, is without mica and gives no clastic residue, the only heavy element being transparent hematite that evidently comes from altered pyrite. Underneath the lower ore body comes laminated clays, in part graphitic, that are evidently derived from decomposed schists but are too incoherent to show distinctly the original structure. These give on sliming a residue of coarse quartz with nodules of earthy iron and manganese oxides

and a small amount of ilmenite, tourmaline and rutile, all of which have the appearance of autigenetic elements.

In the dump a few blocks of harder rock of various types were found which from their rarity and evident sporadic mode of occurrence may be presumed to represent segregated masses in the midst of the predominant type of earthy ore. One of these is a quartz-garnet rock like that already described from Piquiry but without traces of a bisilicate element and with the quartz mosaic in comparatively large grains that suggest a doubt as to whether this mineral is a secondary or primary element. Another highly quartzose type has as a bisilicate element an altered mica and has, as an accessory, yellowish isotropic grains that could not be determined but that give a decided titanium reaction. Still another type is a garnet-amphibole rock with rare grains of secondary (?) quartz and with the garnet full of delicate rod-like inclusions that appear to be acicular amphibole. With the exception of the mica-bearing rock all of these types are identical with those found at Piquiry, though no case of the formation of the secondary asbestus was observed.

At the Agua Limpa locality prospecting operations have revealed an extensive ore body which at the surface is composed mainly of secondary oxide but with a sufficient admixture of garnet to show that this body is also essentially a mass of garnet-bearing rock. A small pit shows underneath the ore a layer of about 20 centimeters thickness of graphitic earth with patches and streaks of white clay and resting on a mass of yellow clay enclosing graphitic patches. The graphitic earth gives much ilmenite but no other recognizable heavy residue, while the white streaks and patches in it give much quartz with a heavy residue of magnetite and malacolized zircon indicating that they probably represent apophyses of the neighboring granite. The yellow clay is massive with small patches of earthy iron and manganese oxides, thus resembling closely, except in color, the clay of the tunnel at Morro da Mina and like that giving a residue of fine quartz with ilmenite partially altered to leucoxene.

In the bed of a small stream a few meters from this pit is an outcrop of perfectly sound amphibole schist consisting principally of two types of amphibole (actinolite and cummingtonnite ?) in a fine mosaic of quartz and feldspar with sphene and a garnet giving a manganese reaction as tolerably abundant accessories. The heavy residue shows a small amount of ilmenite and amongst the smaller garnets yellowish crystals of ideal perfection of form. This rock has every appearance of a recrystallized sheared eruptive, and if so was probably originally of dioritic or gabbroitic type but containing manganese garnet

or, perhaps more probably, a manganese-bearing silicate that has given rise to the garnet in the process of metamorphism. Such a type, if unsheared and decomposed, would give rise to a clay very like that found in the immediate vicinity in the above mentioned pit, and the hypothesis may be ventured that the two represent sheared and unsheared portions of the same rock mass.

On the opposite side of the hill and a few scores of meters to one side of the ore belt pits had been opened in partially decomposed granite with stringers from a few millimeters up to about a meter in width of graphite, which though somewhat mixed with clayey matter appears to be of good quality.

At the Barroso locality, which, as already remarked, appears to mark a third ore belt intermediate between that of Piquiry-São Gonçalo on one side and that of Morro da Mina-Agua Limpa on the other, two openings have been made several hundred meters apart and apparently on independent ore bodies. One exposes a layer about two meters thick and with an inclination of about 45° between walls of decomposed schist threaded with stringers of granite. The ore presents for the most part the aspect of the earthy material at São Gonçalo and like that gives a residue of microscopic garnet but with a greater amount of quartz and of clayey matter. In places it passes to a granular quartz rock thickly sprinkled with macroscopic garnets. The enclosing schist presents an appearance suggestive of an original amphibolite and gives a residue of ilmenite only, and apparently represents a sheared eruptive of non-granitic character. In the other and more important opening the ore body is 4 to 6 meters thick, inclined at an angle of about 80° between walls of decomposed schist without granite. The ore, which is of the same general character as that of the first opening, though of better appearance is quite impure, giving, according to Mr. Scott's analysis of an average sample, 28·10 per cent of metallic manganese, 6·00 per cent of iron, 15·80 per cent of siliceous residue and 7·20 per cent of graphite. Much of the ore has the aspect of a decomposed graphitic clay slate charged with secondary manganese oxide, but one of my samples, too friable for a microscopic preparation, resembles, both in aspect and in its residue, the garnet-quartz rock with mica from Morro da Mina and like that has no graphite. Another specimen showing considerable well-crystallized graphite with ilmenite has the garnet enclosed in an earthy siliceous matrix apparently of secondary quartz stained with iron but not with manganese (except in the portions where the garnet is also decomposed), and this appears to represent an original rock composed of garnet with some iron-bearing silicate. The decomposed schist of the walls of this ore body is still quite

resistant and differs somewhat in aspect from that of the first opening but like that gives only a residue of ilmenite and appears to have been an amphibole schist.

Some 50 to 60 kilometers to the southward of Queluz and in the municipal district of Barbacena is another ore district which I have not had an opportunity of visiting but from which specimens from various points have come to hand. These represent an extension of about 30 kilometers as measured by the railroad line between the stations of Ressaquinha on the north and Sitio on the south. The region, like that about Queluz, is characterized by gneissic rocks abundantly injected with granite. The ores are of two types, of which one, corresponding to that of the Queluz district, consists of a garnetiferous rock impregnated with secondary manganese oxide evidently derived from the garnet. One specimen is heavily charged with well-crystallized graphite and gives in the residue a white amphibole, neither of which minerals have been noticed in the other specimens. The second type is a manganiferous magnetite of which a specimen from near the station of Ressaquina was analyzed by Mr. Scott, who found 11·60 per cent of metallic manganese with 40·08 per cent of metallic iron. The other specimen at hand seems to be somewhat richer in manganese but is still essentially an iron-manganese ore. The appearance of this ores is that of an ordinary finely granular magnetite charged with pulverulent secondary manganese oxide. The origin of this oxide is readily found by dissolving the metallic oxide with hydrochloric acid, which leaves a more or less abundant residue of rather coarse and highly corroded spessartine often reduced by superficial etching to irregular hook-shaped fragments. The original type was therefore a magnetite-spessartine rock from which the silica and alumina of the garnet has been almost completely removed by leaching, leaving a residue of manganese oxide. From another ore district near Paranaguá in the state of Paraná a specimen of identical appearance giving about 12 per cent of metallic manganese is at hand, which appears to represent the same type from which the original garnet has entirely disappeared. This conclusion is confirmed by a specimen received later from the state of Santa Catherina, but in the prolongation of the Paraná ore district, in which, as in the Barbacena ore, a remnant of corroded spessartine is still preserved. In this costal ore district, extending from southern São Paulo to Santa Catherina and embracing the Jacupiranga deposits described by me some years ago in this Journal (April 1891), titaniferous magnetites are very abundant and characteristic, but their relations to these rarer manganese-magnetite ores are not known.

It results from the above observations that the ore bodies of the Queluz district are residual deposits derived through decomposition and leaching from an original type, or types, of rock in which manganese garnet was the most constant and characteristic silicate element. With this, which often constituted almost the entire bulk of the rock, were associated minerals of the amphibole (and perhaps pyroxene) or mica series, and in some phases free manganese oxide that when in predominant proportions gave a type corresponding to that of the free iron oxide (magnetite) and manganese garnet rock of the Barbacena district, or, in more general terms, to the well known types of magnetic or titaniferous iron oxides with various silicates. The occurrence of garnetiferous quartzites appears to indicate that in some cases quartz may also have been a primary constituent, though for the most part it seems to have been of secondary origin. As accessory elements, ilmenite and rutile are of frequent though not of constant occurrence, while apatite, though positively recognized in two specimens only, appears to have been constant since a small proportion of phosphorus has been found in all analyses in which it was looked for. A remarkable feature, considering the highly basic character above deduced for this type, is the absence, except sporadically as ilmenite, of free iron oxide and the low proportion of combined iron as shown by the analyses of the residual ores in which a concentration of this element is presumable. The Barbacena ore, however, shows that, exceptionally, free iron oxide may occur and even rise to a predominant proportion. Another remarkable feature is the tolerably constant, though sporadic, appearance of graphite, though as will be shown below this is probably an introduced element.

This type, which may appropriately be denominated *queluzite*, is more or less intimately associated at São Gonçalo, Morro da Mina and Barroso with decomposed schistose rocks that evidently contained an original manganese-bearing silicate and which from the absence of recognizable clastic elements and from other characteristics, so far as they can be made out, is presumed to have been an amphibolic schist representing a sheared basic eruptive. At Agua Limpa a confirmation of this deduction is afforded through the presence in almost immediate contact with the ore body of a feldspathic amphibole schist containing manganese garnet, which is almost certainly a sheared eruptive and, although its original character cannot be positively determined, probably of dioritic, gabbroitic or noritic character. At Morro da Mina, São Gonçalo and Agua Limpa there is also in close connection with the ore an unsheared eruptive (represented by manganese-bearing clays) which in its original condition must have been of very similar

if not identical type. In the Agua Limpa schist, moreover, the manganese-bearing element is spessartine as in the ore bodies, thus giving greater plausibility to the hypothesis that the relation between these last and the above mentioned rocks may be a genetic one. If thus related, the ore bodies present strong analogies with those of magnetic, titaniferous and chromic iron ores that are now generally considered as magmatic segregations in various types of eruptive, and, all things considered, this hypothesis seems the most plausible one for the manganese ores here discussed. The fact that though carefully looked for, no rock types that could be positively, or even presumably, identified as clastic could be found near the ore bodies, makes the alternative hypothesis of a clastic origin a difficult one to apply. The occurrence of distinct traces of nickel and cobalt in the unaltered ore of the Morro da Mina tunnel may perhaps be also an argument for an eruptive origin, though too much stress cannot, without farther study, be laid upon it, since Mr. Scott reports these elements under totally different conditions near Miguel Burnier in a small patch of secondary manganese oxide that is undoubtedly a secretionary deposit in a decomposed clastic schist.

Through the kindness of Dr. Francisco da Paula Oliveira, director of the geological section in the National Museum of Rio de Janeiro, I have had the opportunity of examining a specimen from a manganese ore body enclosed in granite near Queimados, in the interior of the state of Bahia, that represents another interesting phase of this rock type. The rock is perfectly fresh, showing about equal proportions of large-sized garnets and of pyroxene with a diallage-like cleavage. The garnets, which attain a size of five millimeters or more, are of a light yellow color, becoming perfectly white in thin sections, and give a strong manganese reaction. The pyroxene, when free from staining by manganese oxide, is colorless and glassy and gives an extremely abundant reaction for manganese, which is evidently much more abundant than iron. Aside from a colorless glassy amphibole intergrown with the pyroxene, no other constituents could be recognized and the rock is essentially composed of manganese-garnet and manganese-pyroxene. From such a rock through the replacement of the easily decomposable pyroxene by secondary quartz the type of quartz-garnet rock of Piquiry and Morro da Mina might be produced.* With

* This type might, however, be expected to leave some trace of its lime and magnesia in the form of secondary asbestus, and in this case the most probable representative is the quartz-garnet rock with asbestus, while the similar rock without the latter mineral may be suspected to have come from an original type in which the bisilicate element was perhaps rhodonite, a mineral that has been looked for in vain although it seems natural that it should occur in such an association of manganese-bearing rocks.

it is associated a quartz rock with large well-formed garnets but this has the aspect of vein material.

From an unknown locality in the state of Espirito Santo a specimen is also at hand showing secondary manganese oxide with garnet and well crystallized graphite. The ore that is being exported from Nazareth in the state of Bahia is, judging from a specimen received from the gentleman above mentioned, of the same type as that described from the tunnel at the Morro da Mina. The polianite (?) is coarsely crystalline and strongly predominant in quantity over the garnet, which is in great part replaced by pseudomorphic skeletons of secondary silica. This specimen contains no graphite, but I am informed that a considerable proportion of the Nazareth ore is graphitic.

The almost constant occurrence of graphite with these manganese-bearing rocks is very suggestive of a genetic relation, as is also the converse association noted by Weinschenk in the graphite deposits of Bavaria and Bohemia. It is not, however, uniformly distributed throughout the ore bodies, as might be expected if the relation was a necessary one, and, moreover it occurs also quite independent of the manganese-bearing rocks as in the granite at Agua Limpa and in a decomposed schist a kilometer or more distant from São Gonçalo. In the former case the graphite appears in both the granite and manganese-bearing rock but in greater force and purity in the former. In the latter the graphite-bearing rock has no manganese ores in the immediate vicinity and the garnets with which it is abundantly charged give no trace of that metal. This schist is also heavily charged with iron in the form of a fine hematite dust and it may be presumed to have been originally a garnet-amphibole schist, or perhaps an eclogite. This is not the place to discuss the probable origin of the graphite, but it may be remarked that the hypothesis of a gaseous introduction propounded by Weinschenk for the Bavarian and Bohemian occurrences seems to me to best meet the conditions observed in this district. Whatever may be its mode of origin and admitting a doubt as to a necessary connection between graphite and manganese-bearing rocks, it is worthy of note that the two elements carbon and manganese certainly show a predilection for each other's society.

São Paulo, Brazil.

ART. III.—*On the Bituminous Deposits situated at the South and East of Cárdenas, Cuba;* by HERBERT E. PECKHAM.

IT is a well known fact that different forms of bitumen exist upon the Island of Cuba. Mention has been made of their occurrence by several writers as long ago as the beginning of the 19th century. In 1803, Alexander von Humboldt visited the island and remained some two years, during which time he studied the geology of the country around Havana and to the eastward towards Matánzas. In 1837, we find Richard C. Taylor, the noted geologist, making an investigation of a so-called coal field at Guanabacoa, six miles east of Havana, and a short report on the same. The same author also mentions the occurrence of springs of liquid bitumen upon the shores of Havana Harbor, and also the fact that the chapapote or maltha was used by the inhabitants for pitching the bottoms of ships. These two references show that bitumen in Cuba has been observed by travelers for over one hundred years. The native population really know more than any one about the location of these outcrops, as is quickly seen when a prospector makes inquiries. While the Spanish Government held control of Cuba there was very little incentive for any one, foreigner or native, to investigate the mineral resources of the island, because of the exorbitant royalties made payable to the Crown; consequently, it is a question whether any one possesses accurate knowledge upon the extent to which bitumen occurs. However, I think enough has been done to show that there can be no doubt that valuable deposits probably exist over a very wide area.

Before the outbreak of the Spanish-American war many scientific travelers had visited the island, making observations covering a much larger area than that mentioned by the earlier writers. From the reports of these travelers, especially Americans and Englishmen, we notice that, so far, the greater number of these occurrences have been observed in Matánzas and Santa Clara provinces. These are so situated geographically that we find solid bitumen extending along the northern coast from Havana eastward as far as Cárdenas. Inland to the south of Cárdenas and eastward the bitumen is more fluid until at Motembo we find a well producing colorless naphtha; while still farther east in the vicinity of Sagua la Grande more dense material reaches the surface. Still farther south and east, at Santa Clara City and in the hills beyond, extensive deposits of solid asphaltum again appear. Roughly estimated, the tract of country exhibiting surface indications of fluid

bitumens of varying density, and yielding in a few instances still more fluid bitumens from wells, covers an area 150 miles long and 30 wide. Motembo, with its naphtha well, is near the center. Other wells and springs in large number throughout this tract have exhibited petroleum and maltha of varying density. It was my intention to have examined the principal localities where bitumen occurs throughout this region, but the rainy season with unusually heavy rains came on four weeks earlier than usual, rendering the portions of the country beyond the reach of railroads inaccessible. I, however, had

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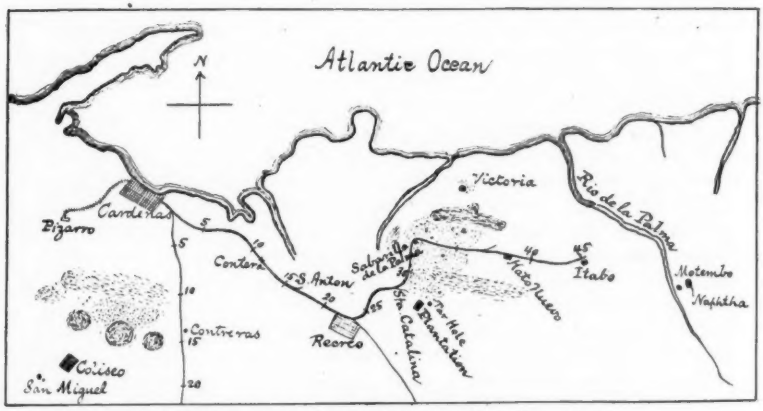


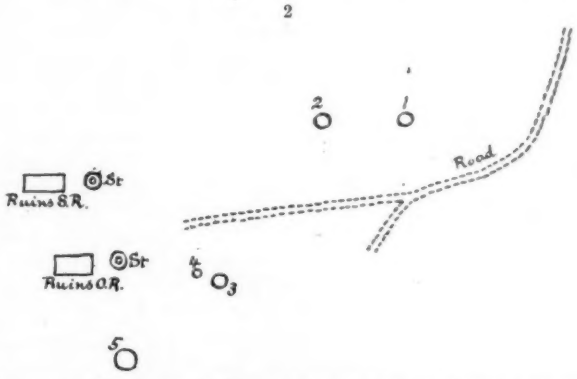
CÁRDENAS AND VICINITY (Pen sketch by the author).

the good fortune to spend some weeks in looking up a few of the places where bitumen occurs in the vicinity of Cárdenas, and to a distance of 40 miles to the eastward. The traveling was done by railroad and on horseback and enabled me to study the immediate surface of the country. The city of Cárdenas is built on a bay of the same name. The shores are low and consequently the bay is shallow. Both to east and west are swamps which in the rainy season are full of water.

Directly south of Cárdenas, some eight or nine miles, is a steep ascent, two or three hundred feet high, on the top of which is a plateau. This plateau extends still farther south to a higher range, 15 miles from Cárdenas. The country between the coast and the plateau first mentioned is level and dry, except a comparatively narrow strip bordering upon the ocean. A great deal of this country is rough, with a limestone that interferes with its cultivation, rendering it of little pecuniary value. This limestone is so plentiful that a great

many walls have been made of it to serve the purpose of fences. When in the ground it is soft and easily cut into blocks of any shape for building purposes. Put up in the soft state, it hardens in about a year and resists the elements for a very long time. Along with this limestone are seen outcrops of serpentine—a greenish mineral—soft and easily broken. The surface soil is a red clay and very productive. Among the trees the royal palm predominates, but there are also cocoanut trees, bananas, mangoes and others.

Looking at the accompanying map, we see this first range of hills directly south of Cárdenas. The trip to this range is best made on horseback. Reaching the plateau, it is found to be about four miles wide, covered with wild grass and royal palms.



Sketch map of the Alvarez Oil Wells; showing also the ruins of the Sugar Refinery (S. R.), Oil Refinery (O. R.) and adjoining Stacks (St.)

Distance between No. 1 (oil and water) and No. 2 (water). 120 meters: between No. 2 and No. 3 (oil, 100,000 gallons), 320 meters; between No. 3 and No. 4, 320 meters; between No. 4 and No. 5, 150 meters.

The hills or low mountains still farther to the south are much higher than the first ascent and covered with trees to within a short distance of the top. To the right spreads an open country formerly cultivated but fast reverting to a wild condition. Directly in front we notice the ruined smoke stacks of two refineries. To the left is spread a broad expanse of this tableland covered with a very peculiar growth of royal palms. These trees, because of some lack of nourishment or deleterious substance in the soil, have been so stunted that they are of all heights, from a mere tuft of leaves sticking out of the ground to fifty or sixty feet; average height ten to twenty feet. This peculiar growth is indicated on the map by the dotted area. It is about five or six miles long and two broad.

Figure 2 gives a larger plan of the refineries just mentioned. These were owned and operated by a man named Alvarez, and

his associates. It is about five years since anything was done here. At the first Alvarez had only his house and the sugar mill. While digging a well for water (No. 1 on the map) they went down 78 feet, obtaining a water that was worthless because of a black thick oil found with it. This being unfit for drinking purposes, another well was dug at No. 2. Water was obtained at 78 feet with only a slight trace of oil. This well was used for water and furnished all there was on the premises. The water in this well is now 39 feet deep. For some years after this, Alvarez gave the oil from well No. 1 to the native population for various domestic purposes and especially for fuel. Then he with others conceived the idea of drilling a well for oil alone and refining it. An engineer and the necessary machinery were procured and well No. 3 drilled. A large hole was put down about 25 feet, inside of which a two-inch pipe was driven down 500 feet, when oil was obtained. A pump was then put in and 100,000 gallons extracted, which was all the well would yield. It was then decided to drill this well still deeper, but the drill became smeared with oil and drillings to such an extent that the drilling was stopped. To obviate this difficulty another well was put down at No. 4, three feet from No. 3, with the idea that when the same depth was reached at which the trouble occurred, the sticky stuff could be pumped out through No. 4 and drawn away from the drill in No. 3. The machinery was attached to the same walking-beam as that which was drilling No. 3, but when the same depth was reached as that of No. 3 no oil was found. No. 4 was then abandoned and another well put down at No. 5, 150 meters to the southwest of No. 3. This well was sunk to a depth of 180 feet, when the drill broke into a subterranean hole and the drills were lost. After some time spent in fruitless effort to recover the drills, everything was pulled up and taken back to well No. 3, to sink it still deeper by using better and improved machinery. An engineer was engaged from the United States to do the work, when one of the principal owners in the enterprise died and all operations were stopped. After the war broke out between Spain and the Cuban insurgents, both of the refineries were burned and nothing has been done there since. The foregoing history was told to me by one Juan P. de Torrontequi, who was one of those actively interested in all that was done. He now lives in Cárdenas. It shows that oil was found in two wells, one of which yielded 100,000 gallons, which were refined and sold to the people in the vicinity; also, that considerable work has been done in drilling, but in a very crude way.

At present the refineries and house are in ruins. The walls, chimneys, and portions of the machinery are all there is in

sight. Well No. 1 is eight feet in diameter walled down to the bed-rock and cut out of the rock for the rest of the distance. There are the remains of a wooden platform inside, about five feet down, which is covered with dirt and weeds. Vegetation is very rank all about it. Well No. 2 is ten feet in diameter, and has a high, strong stone coping around the top. Water at the bottom can easily be seen. Some water obtained from this well showed a trace of oil on the top. At well No. 3 about three feet of two-inch cast iron pipe sticking out of the ground is all that can be seen. Wells No. 4 and 5 have been filled up and all traces obliterated. The sample of oil obtained from No. 1 is very black, and of about the consistency of thin molasses with a strong odor.

After inspecting this property, I was shown a natural oil spring, a quarter of a mile distant from these wells, toward the poor land covered with stunted palms. A small stream or creek runs to the southeast, from the banks of which I saw oil oozing at several points. In appearance it was the same as that found in well No. 1. A Cuban told me that there were several such places along this creek and that the natural springs were plentiful in that vicinity.

Some time after the visit to the Alvarez property another trip was made to Sabanilla, about 30 miles directly east of Cárdenas. What was formerly the town of Sabanilla de la Palma is now a mass of ruins, so I went to Hato Nuevo, the next station to the east and 37 miles from Cárdenas. The way to reach this place is indicated on fig. 1 accompanying this report. As this tract is the largest I visited, I will describe my journey in detail. My interpreter and myself arrived in Hato Nuevo one afternoon about three o'clock. The next morning with two other men we set out to find the indications of bitumen. Following the railroad, we went west toward Sabanilla about two miles. Crossing the railroad, we struck out to the west in a zigzag course until, after riding about a mile, we arrived at a place where the ground is as hard as a floor and black with bitumen. There was a hole in the middle of this tract from whence issues a soft maltha that is very sticky. This has come out of the ground and flowed in all directions, saturating everything. Several other holes of a like nature were found and altogether covering nearly half an acre of ground. In one corner of this tract a square hole had been dug and walled up. During the late war this hole was fired and burned for four months until a heavy rain finally put it out. At present the ground for seventy or eighty feet around this hole is covered with coke. The well itself is full of water from rains and upon this floats masses of vegetation stuck together with the bitumen that comes from below. A pole shoved downward into the water eight or nine feet meets

resistance in a bed of soft, yielding material, and if this can be brought to the surface it is seen to be the same as that in the neighborhood. In the center of some of these springs were bubbles as large as walnuts which, when broken, quickly collapsed with some noise. Inside of the bubble was a small hole going down into the ground, indicating the possibility that the bubble was caused by gas. Many other overflows showed holes but no bubbles. The consistency of this material is like that of ordinary coal tar.

From this place we took a path in a southwesterly direction, through cane fields and waste lands, and after riding about three miles we reached an abandoned sugar plantation named Victoria. This place is a natural occurrence in a depression resembling a crater. The out-crops of bitumen here are not only larger in area than at the first place visited, but in quantity as well. There is also a hole here which had been dug, and during the war it was fired and burned for two months. A great deal of coke could be seen all around its edges. In at least two dozen places among a tall grass and low shrubbery, I saw holes from which bitumen was flowing in great quantity. Around some of them were beds of bitumen several feet in diameter, radiating quite uniformly from the center. The center was very soft and easily dug out. Upon several of the holes, as at the other place, I found bubbles which burst upon being struck. Our Cuban guide said these holes had been known for many years and that some of them had been much bigger than they are now. One of them in particular had caused the death of many cattle, which had fallen into it, and being unable to get out, had perished. The guide said the natives had been years trying to render this hole harmless to cattle by filling it with stones. It was then nearly full. All of the holes I saw covered, I should say, about two acres. Still farther to the west the guide pointed out a clump of palms, and said there were more holes under them. I did not go there. They were a mile and a half distant.

From here we struck out to the west, and a little south towards the railroad, to the ruins of Sabanilla de la Palma. The country through here is level and covered with a grass eighteen inches high. As we passed through here we saw several other depressions filled with water, and holes from which this same black, sticky stuff was flowing. Around the surface of some of these lagoons we observed bubbles constantly rising, indicating the presence of gas. One of these isolated holes is within one hundred feet of the railroad and shows considerable activity. On the south side of the track is another hole in the bottom of an excavation about twenty-five feet long, twenty feet wide, and six feet deep. This had been on

fire and burned for one month. Coke could be seen all about it, as at the other places. After a mere glance at this place, we took a path which led around the western end of the range of hills on the south side of the railroad, and after passing through a country overgrown with high grass and rank tropical vegetation, on what used to be a sugar plantation, we came out at another natural spring on a plantation near Santa Catalina, as indicated upon the map. Here is a natural spring and beside it a round hole ten feet in diameter, which was full of water. The guide said that this hole was almost bottomless and that the material had been used for repairing the buildings on the plantation half a mile distant. A fifteen-foot pole was shoved down into the water. At ten feet it struck the soft mass on the bottom. I shoved the pole still farther downward until there was scarcely a foot of the pole left in my hand, but no solid bottom was reached. This was the largest artificial well I saw and helped to prove to me that the evidences show this material to be well-nigh inexhaustible. From here we made our way back to Hato Nuevo as quickly as possible, and the next morning went back to Cárdenas.

The country where these evidences occur is very peculiar. The railroad from Recreo to Hato Nuevo passes through what resembles a river bottom. On the left are low hills in scattered clumps or standing quite alone. On the right the land is level until we reach the turn in the railroad at Sabanilla. Here a ridge commences and thence forward there are hills on both sides of the railroad to Hato Nuevo and beyond. This forms a plain between two ranges of hills. This plain is covered with the same kind of vegetation as that on the tableland south of Cardenas.

As the occurrences at Victoria are found on the north side of these hills, I am inclined to believe there are other bituminous hills between them and the coast. This embraces a territory of many square miles in extent.

I had very much wished to visit the celebrated naphtha well at Motembo, but the Rio de la Palma was so high as to be unfordable. I was told that the owner had done some drilling there in a very crude way and that the product was singularly pure. He used it like gasolene for heating and lighting his house. I have no personal knowledge of this place. The naphtha from this well has been gathered and distributed so widely as to be well known. It is of the specific gravity of ordinary benzine, and is absolutely colorless. A short description of the well and the locality surrounding it is to be found in the Mineral Resources of the United States for 1898 and '99. There is no question that this locality, as has been before stated, lying midway between two areas producing petroleum

and maltha, with solid asphaltum marking extremes still further removed from the center on either side, represents an unusual showing of bituminous deposits.

I was also told of another oil and water spring at San Miguel near Coliseo, twenty-one miles south of Cárdenas. As this spring was so full of water as to render it impossible to obtain any of the oil, I did not attempt to visit the place. A Cuban in Cárdenas who was familiar with the locality told me that the oil flows out of this spring into the water in such quantity as to cause cattle to refuse to drink the water.

It has been known for many years that solid asphaltum exists in the bottom of Cárdenas Bay. I was given a piece by a man in Cárdenas who said he had been mining it for many years and sold it in New York for from forty to seventy dollars a ton. It appears to be a very fine quality.

The occurrence of yellow fever at Santa Clara City prevented me from visiting that locality, but I was told there are large deposits of bitumen there. A sample of oil from a spring in this neighborhood called the "Sandal-wood Spring" was examined by Mr. H. N. Stokes in July, 1890, in the laboratory of the United States Geological Survey, in Washington, D. C. This examination was quite elaborate, and determined that the oil was closely allied to Russian oil. This gives the oil a value which, while it is a little inferior to the best Pennsylvania oils, is ranking among the best petroleums of the world, and particularly available for the preparation of lubricating oils.

Although I was unable to ascertain by personal examination the presence of liquid bitumens in the neighborhood of Sagua la Grande, I was assured by one whom I have every reason to believe, that there are very extensive deposits in the neighborhood of this town and extending eastward to Caibarien. This territory is fully if not quite as large as the one at Hato Nuevo.

From all of the information herein recited, obtained from varying and reliable sources, the following conclusions may be drawn:

That very extensive deposits of solid asphaltum exist near the north coast of Cuba. That springs and wells give indications of the existence of liquid bitumens of varying density, beneath the surface, over an area of some 4500 square miles. That the place in the modern geological series to which the formations in which the bitumens occur has not been determined, a fact of little practical importance, but the occurrence of fluid bitumens associated with serpentine has been before observed both in southern France and in California. The oil

which has been obtained resembles the oils of Russia, hence may be easily manufactured into commercial articles.

Remarks on the Same

By S. F. Peckham..

Having carefully read this paper upon the Bituminous Deposits of Cuba, and while expressing the fullest confidence in what is said therein, I am prepared, in consequence of my experience with such indications in California and elsewhere, for that reason, to make the following statements.

Until a sufficient amount of work has been done by parties personally interested in this property, to demonstrate beyond question the existence upon or under it of actual value, these surface indications, though exhibited on a large scale and over a wide area, are not in any manner in themselves a source of prospective wealth but are rather only an incentive to cautious and very careful prospective drilling. The wells that have been drilled, while demonstrating that oil can be procured by drilling, have been very moderate producers and extremely short-lived and are, therefore, quite as largely indications to extreme caution as a stimulus to even experimental outlay. It is doubtful if, in view of the enormous production which recent developments in Texas and Indiana promise, there is at present any encouragement for even experimental drilling in Cuba.

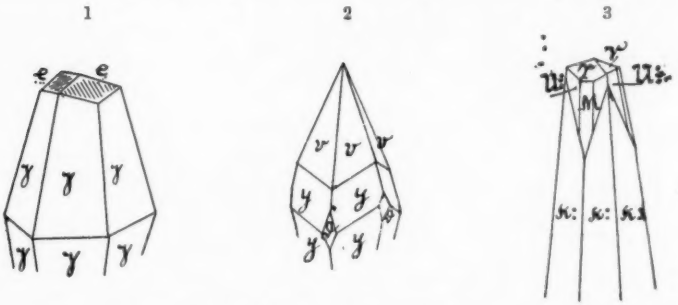
It has long been known that very extensive deposits of asphaltum exist in Cuba, but I have never seen a sample that I was sure came from there, that was of such quality as to compare well with varieties upon the market from other localities within the borders of the United States.

ART. IV. — *Mineralogical Notes, No. 2;* by AUSTIN F. ROGERS, Fellow in Mineralogy, Columbia University.

1. *Calcite.**

(*a*) *New Types from the Upper Mississippi Lead Region.*— The calcite crystals occurring in the ore district of southern Wisconsin have been studied by Hobbs,† who distinguishes six types of crystals with 13 forms. In the Egleston Mineralogical Museum of Columbia University are three types not mentioned by Hobbs, including three forms not given by him.

The most interesting type is represented by two singly terminated crystals about 20×30^{mm} with a fewer smaller ones, and are labelled "Shullsburg, Wis." The dominant form is the pyramid of the second order γ $(8{\cdot}8{\cdot}\bar{1}\bar{6}{\cdot}3)$, a rare form for calcite first observed by vom Rath‡ on Andreasberg crystals, and later by Cesaro§ as a dominant form on crystals from



Rhisnes, Belgium. Hamberg‖ also found it on crystals from Visby, Gotland, Sweden; and recently Penfield and Ford¶ described some siliceous calcites from Bad Lands, South Dakota, on which this pyramid is the dominant form. Penfield and Ford** have also described crystals from Union Springs, Cayuga Co., N. Y., on which this form is prominent.

The only other forms occurring on the Shullsburg crystals are the negative rhombohedron $e(01\bar{1}2)$, faces of which are

* Letters given by Dana in 6th Edition System are used for such forms as are mentioned therein. Goldschmidt's letters are used for the other forms. The letters for new forms are chosen in accordance with Goldschmidt's table on p. 141 of vol. i of his "Index der Krystallformen der Mineralien."

† Hobbs. Zeitschr. f. Kryst., xxv, 258–261, 1895: also Bull. Univ. Wis., Sci. Series, i, 114–121, 1895.

‡ vom Rath, Pogg. Ann., cxxxii. 521. 1867.

§ Cesaro, Mem. l'Acad. Roy. de Belgique, xxxviii, 8–14, 1886.

‖ Hamberg, Geol. Fören. Förhandl., xvi, 709–716, 1894.

¶ Penfield and Ford, this Journal, ix, 352–354, 1900.

** Penfield and Ford, this Journal, x, 237, 1900.

striated parallel to their shorter diagonal, and a narrow undetermined negative scalenohedron beveling the alternate polar edge of γ. Figure 1 represents a crystal of this type.

One of the smaller crystals was used for the identification of the forms. It did not give very satisfactory images with the reflection goniometer, but the faces are identified.

			Average.	Calculated.
$\gamma \wedge \gamma^{I}$	$8\cdot8\cdot\bar{1}\bar{6}\cdot3 \wedge 16\cdot\bar{8}\cdot\bar{8}\cdot3$	3	59° 0′	58° 28′
$\gamma \wedge \gamma^{VI}$	$8\cdot8\cdot\bar{1}\bar{6}\cdot3 \wedge 8\,8\cdot\bar{1}\bar{6}\cdot\bar{3}$	5	24° 29′	24° 46′

The average of 10 measurements on the hand goniometer gave for $e \wedge e\ (01\bar{1}2) \wedge (1\bar{1}02)$ 45° 54′, the calculated being 45° 3′.

On another type of crystals 5 to 10^{cm} long, the forms v $(21\bar{3}1)$, y $(32\bar{5}1)$, f $(02\bar{2}1)$ and ϑ $(10\cdot0\cdot\bar{1}\bar{0}\cdot1)$ occur. Ordinarily v is the dominant form as in figure 2, but at times y assumes that rôle, while on several corroded crystals v is apparently absent.

Crystals of this type are from Mineral Point and Shullsburg, Wis., and Dubuque, Iowa. Measurements were made with the contact goniometer.

Still another type occurs at Miflin, Wis. The forms are $\mathfrak{K}$: $(8\cdot4\cdot\bar{1}\bar{2}\cdot1)$, v $(21\bar{3}1)$, e $(01\bar{1}2)$, r $(10\bar{1}1)$, ϑ $(10\cdot0\cdot\bar{1}\bar{0}\cdot1)$. $\mathfrak{K}$: the dominant form is rather rough, v is smooth, e is striated and r is very much corroded: ϑ is a very narrow form truncating the obtuse polar edges of $\mathfrak{K}$:. On account of their large size ($2\frac{1}{2}$–5^{cm}) measurements were made with the contact goniometer with these results:

				Av.	Calc.
$\mathfrak{K}: \wedge \mathfrak{K}:^{I}$	$(8\cdot4\cdot\bar{1}\bar{2}\cdot1) \wedge (\bar{8}\cdot12\cdot\bar{4}\cdot1)$	5	80° 52′	81° 20′
$\mathfrak{K}: \wedge \mathfrak{K}:^{V}$	$(8\cdot4\cdot\bar{1}\bar{2}\cdot1) \wedge (12\cdot\bar{4}\cdot\bar{8}\cdot1)$	4	38° 18′	38° 2′
$\mathfrak{K}: \wedge \mathfrak{K}:^{VI}$	$(8\cdot4\cdot\bar{1}\bar{2}\cdot1) \wedge (4\cdot8\cdot\bar{1}\bar{2}\cdot\bar{1})$	6	24° 45′	24° 21′
$v \wedge v^{I}$	$(21\bar{3}1) \wedge (\bar{2}31\bar{1}$	3	75° 30′	75° 22′
$v \wedge v^{V}$	$(21\bar{3}1) \wedge (3\bar{1}\bar{2}1)$	3	35° 40′	35° 36′

(b) Calcite with a new form from Colorado.—Some calcite crystals from Seguache Co., Colorado, obtained from Geo. L. English & Co., are different in habit from any described from this country (figure 3). The forms observed are $*\kappa$:, $(49\cdot41\cdot\bar{9}\bar{0}\cdot8)$, $\mathfrak{U}$: $(24\cdot8\cdot3\bar{2}\cdot7)$, r $(10\bar{1}1)$, m $(40\bar{4}1)$, e $(01\bar{1}\bar{2})$, c (0001). κ:, new for calcite, is the dominant form. The faces are bright and give excellent images except e and c, which are striated or roughened. These were identified by their position, the former truncating the polar edge of r. The following measurements made with the reflection goniometer identify the forms.

			Limits.	Average.	Calc.
$\kappa \wedge \kappa:^{I}$	$(49\cdot41\cdot\bar{9}\bar{0}\ 8) \wedge (\bar{4}\bar{9}\ 90\cdot\bar{4}\bar{1}\cdot)8)$	7	65° 28′–65° 30′	65° 29′	65° 29′
$\kappa \wedge \mathfrak{K}:^{V}$	$(49\cdot41\cdot9\bar{0}\cdot8) \wedge (90\cdot\bar{4}\bar{1}\cdot\bar{4}\bar{9}\cdot)8)$	6	53° 48′–53° 49′	53° 49′	53° 48½′
$\mathfrak{U}: \wedge M$	$(24\cdot8\cdot\bar{3}\bar{2}\cdot7) \wedge (40\bar{4}1)$	3	13° 30′–13° 31′	13° 30½′	13° 29′
$\mathfrak{U}: \wedge \mathfrak{U}:^{I}$	$(24\cdot8\cdot\bar{3}\bar{2}\cdot7) \wedge (\bar{2}\bar{4}\cdot32\cdot8\cdot7)$	3	88° 48′–88° 49′	88° 48½′	88° 48½′
$r \wedge M$	$(10\bar{1}1) \wedge (\bar{4}04\bar{1})$	3	31° 9′–31° 11′	31° 10′	31° 10½′

There is no doubt as to the symbol given for κ: being the correct one though it is complicated. The images were excellent and the crystal was recentered several times. The nearest known form is $(6{\cdot}5{\cdot}\bar{1}\bar{1}{\cdot}1)$, for which the calculated angles are 65° 36′ and 53° 40′ instead of 65° 29′ and 53° 48½′ respectively.

(*c*) *New form on Calcite from Frizington, England.*—The small acicular calcite crystals from Frizington, Cumberland, England, seem not to have been described.

The forms identified are as follows: *m* $(10\bar{1}0)$, *a* $(11\bar{2}0)$, *χ $(5{\cdot}5{\cdot}\bar{1}\bar{0}{\cdot}1)$, *v* $(21\bar{3}1)$ *r* $(10\bar{1}1)$, *e* $(01\bar{1}2)$, and a negative scalenohedron probably *B* $(2{\cdot}8{\cdot}\bar{1}\bar{0}{\cdot}3)$ and an undetermined dihexagonal prism. The pyramid of the second order χ, new for calcite, is the dominant form. The following measurements were made with a No. 2 Fuess goniometer with diminishing eye-piece. The measurements made over adjacent polar edges of the pyramid show conclusively that it is not a scalenohedron.

			Limits.	Av.	Calc.
$\chi \wedge \chi^{I}$	$(5{\cdot}5{\cdot}\bar{1}\bar{0}{\cdot}1) \wedge (10{\cdot}\bar{5}{\cdot}\bar{5}{\cdot}1)$	4	59° 33′–59° 35′	59° 34′	59° 34½′
$\chi \wedge \chi^{v}$	$(5{\cdot}5\,\bar{1}\bar{0}\,1) \wedge (\bar{5}{\cdot}\bar{5}{\cdot}10{\cdot}1)$	4	59° 34′–59° 35′	59° 34½′	

(*d*) *Calcite Crystals from Eudora, Kansas.*—In cavities of the brachiopod fossil *Enteletes hemiplicata*, which occurs so abundantly in limestone at Eudora, Douglas Co., Kansas, are found small colorless calcite crystals.

The observed forms are σ $(51\bar{6}4)$, *r* $(10\bar{1}1)$, *e* $(01\bar{1}2)$, *l* $(04\bar{4}5)$, *M* $(10\bar{1}0)$, *t* $(21\bar{3}4)$, *m* $(10\bar{1}0)$. σ is ordinarily the dominant form, though sometimes *r* is. The faces are somewhat striated and otherwise imperfect. Consequently the measurements are not all good, but they serve to identify the forms without question.

			Average.	Calc.
$\sigma \wedge \sigma^{I}$	$(51\bar{6}4) \wedge (\bar{5}61\bar{4})$	2	14° 19′	14° 27′
$\sigma \wedge \sigma^{v}$	$(51\bar{6}4) \wedge (61\bar{5}4)$	2	78° 2′	77° 54′
$e \wedge l$	$(01\bar{1}2) \wedge (04\bar{4}5)$	2	11° 50′	12° 2′
$l \wedge m$	$(04\bar{4}5) \wedge (10\bar{1}0)$	2	51° 39′	51° 43′
$m \wedge M$	$(10\bar{1}0) \wedge (40\bar{4}1)$	2	14° 15′	14° 17′
$t \wedge e$	$(21\bar{3}4) \wedge (01\bar{1}2)$	1	21° 0′	20° 58′

(*f*) *Calcite Crystals from Kansas City, Mo.*—Dull opaque calcite crystals from 1 to 3^{cm} in length, occurring in a limestone at Kansas City, Mo., present some peculiar features. They are singly terminated and are always attached at the terminated end. The other end is hollowed out and occupied by parallel growths. They would scarcely be called crystals were not the rough faces seen to be definitely related to the cleavage planes. The forms are *g* $(05\bar{5}2)$ and *n* $(50\bar{5}1)$, rare rhombohedrons for

calcite. g consists of smooth narrow faces truncating the polar edges of n. The faces of the latter are very rough, channeled parallel to their intersection edge with g, and pitted. The angle $g \wedge r$ (cleavage face) $05\bar{5}2 \wedge 10\bar{1}1$ was measured with the following results, the contact goniometer being used.

		Average.	Calculated.
Crystal 1	8 measurements	67° 25′	67° 30′
" 2	6 "	67° 55′	67° 30′

The form n was identified by the fact that the g face truncates its polar edges, as measurements were not possible on account of the rough surface.

2. *A New Form on Galena.*

Several crystals of galena associated with sphalerite and calcite from an unknown locality are thought to be worthy of brief mention here. The forms present are the tetragonal

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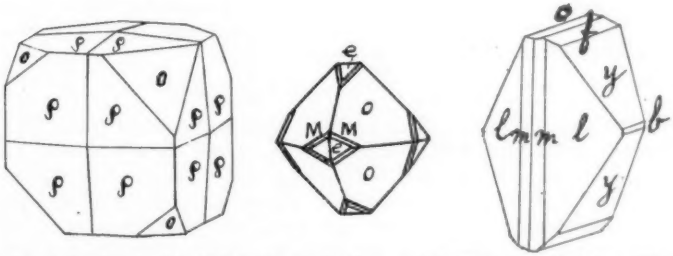

trisoctahedron *ρ (13·1·1) and the octahedron o (111). The crystals have a tetrahedral aspect due to the unequal development of the octahedral faces (fig. 4). ρ (13·1·1) is a new form for galena and is not mentioned as occurring on any isometric mineral in the 6th edition of Dana's System. It is striated parallel to its intersection edge with the octahedron, but good measurements were obtained, as the following table shows.

			Limits.	Average.	Calc.
$\rho \wedge \rho$	13·1·1 $\wedge$ 13.$\bar{1}$.1	4	8° 44′– 8° 48′	8° 46′	8° 46′
$\rho \wedge o$	13·1·1 $\wedge$ 1·1·1	3	48° 29′–48° 32′	48° 30′	48° 31½′

3. *Pyrite Crystals from Weehawken, N. J.*

Occurring in the calcite veins of the trap near Weehawken, N. J., are found small crystals of pyrite with the following forms o (111), e (210), M (432), the latter as narrow faces truncating the edge e/o. Figure 5 gives an idea of their habit. The markings, equilateral triangles on o and isosceles triangles on e, are almost identical with the etch figures, and like them indicate

the symmetry of the crystal. The diploid is sometimes lacking and occasionally the pyritohedron and octahedron are in equal development, the crystals then simulating the regular icosahedron of geometry. On account of striations good images were not obtained, and in the case of the diploid the reflections had to be relied upon. The measurements are as follows:

		Average.	Calculated.
$M \wedge o$ 432 $\wedge$ 111	7	15° 16′	15° 13½′
$e \wedge o$ 210 $\wedge$ 111	3	39° 14′	39° 14′
$e \wedge e$ 210 $\wedge$ 2$\bar{1}$0	3	53° 29′	53° 7¾′

4. *A Topaz Crystal of Unusual Habit from Pike's Peak.*

A topaz crystal from Pike's Peak, Col., measuring ($25 \times 20 \times 15^{mm}$) differs in habit from most of the described crystals. See figure 6. The forms present are *c* (001), *b* (010), *m* (110), *l* (120), *f* (021), *y* (041), and a small undetermined pyramid of the unit series. *l* and *y* are the dominant forms and the crystal is lengthened in the direction of the *a*-axis. *m* and *l* are vertically striated and the other faces are dull. The forms were identified with the contact goniometer.

5. *A new locality for Leadhillite.*

The rare mineral leadhillite has been reported from but three localities* in this country. The writer here records the mineral from a new locality, namely the Cerro Gordo Mines, Inyo Co., Cal. It occurs as small imperfect crystals of a pale sea-green tint on a specimen associated with linarite and caledonite. The crystals are short prismatic or thick tabular, of hexagonal aspect, much resembling those from Granby,† Missouri. The following forms were observed: *c* (001), *m* (110), *a* (100), and a narrow face in the vertical zone which could not be identified on account of its small size. The crystals were not suitable for measurement. There is perfect cleavage parallel to *c* and the cleavage plates have a high pearly lustre. The mineral is soluble in HNO_3 with effervescence leaving a white residue.

6. *Linarite Crystals from California.*

No linarite crystals have been described from the United States though it is known to occur at three localities.‡ The crys-

* Newberry Dist., Spartanburg Dist., N. C., by Shepard, Dana Min. 6th edit, p. 922, 1892. Schultz Gold Mine, Arizona, by Penfield, ibid. Granby, Mo., Pirsson and Wells, this Journal, vol. xlviii, p. 219–226, 1894.

† Pirsson and Wells, loc. cit.

‡ Cerro Gordo mines, Inyo Co., Cal., Dana's System, 6th edition, p. 925, 1892. Stevenson Bennett mine, near Las Cruces, New Mexico, Farrington, Publications Field Columbian Museum, Geol. Series, vol. i, no. 7, p. 225, 1900. Galena, Kansas, Rogers, Kansas Univ. Quarterly, vol. ix A, p. 165, 1900.

tals from Cerro Gordo mines, Inyo Co., Cal., present the following forms: *c* (001), *a* (100), *m* (100), *b* (010), *u* ($\bar{2}01$), *s* ($\bar{1}01$). The crystals are very thin, being flattened parallel to the hemi-orthodome *s* ($\bar{1}01$) and are elongated in the direction of the *b*-axis. Good measurements were not obtained on account of narrow faces and multiple images, but they are sufficient to identify the forms as given above.

This mineral also occurs at the Alice mine, near Butte City, Mont., and at the Daly mine, Park City, Utah.

7. *Caledonite Crystals from Montana.*

Caledonite has been reported from the same three localities as linarite. Its occurrence at Mine la Motte, Mo., needs confirmation. The crystals examined are from the Alice mine, near Butte City, Montana. They resemble in habit those described by Farrington* from New Mexico. The forms are *c* (001), *b* (010), *m* (110), *e* (011), *f* (021), *s* (223), *t* (221, besides several undetermined vicinal forms between *f* and *c* and between *t* and *m*.

8. *Highly modified Barite Crystals from Kansas City, Mo.*

In cavities in limestone at Kansas City, Mo., are often found small crystals of barite. They are usually simple combinations of the common forms, but occasionally highly modified ones are found. One such measuring about $1\frac{1}{2}^{mm}$ (fig. 7) was studied with the following results. The crystals are tabular in habit, being flattened parallel to the basal pinacoid. The forms are as follows: *c* (001), *b* (010), *a* (100), *m* (110), *L* (140), η (320), *l* (104), *d* (102), *o* (011), *f* (113), *r* (112), *z* (111), *y* (122). Not all the faces gave good images, but the forms are identified without doubt.

				Average.	Calculated.
a ∧ *d*	100 ∧ 102	3		51° 6′	51° 8½′
l ∧ *c*	104 ∧ 001	5		21° 54′	21° 57′
c ∧ *d*	001 ∧ 102	3		38° 51′	38° 51½′
c ∧ *o*	001 ∧ 011	3		52° 38′	52° 43′
m ∧ *z*	110 ∧ 111	3		25° 39′	25° 41′
r ∧ *c*	112 ∧ 001	3		46° 10′	46° 6′
f ∧ *c*	113 ∧ 001	3		34° 45′	34° 43′
c ∧ *y*	001 ∧ 122	5		56° 51′	57° 1′
a ∧ *m*	001 ∧ 110	3		39° 11′	39° 11′
η ∧ *m*	320 ∧ 110	8		10° 29′	10° 39′
b ∧ *L*	010 ∧ 140	6		22° 40′	22° 14½′

* Farrington, loc. cit.

9. *Celestite Crystals from Salina Co., Kansas.*

The writer is indebted to Dr. J. W. Beede for some crystals of celestite obtained at a quarry east of Mentor, Salina Co.,

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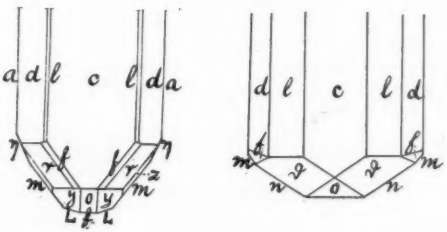

Kansas. As far as can be learned no celestite crystals have been described from Kansas, though it is a common mineral at several localities in the state.

The crystals, one of which is represented by fig. 8, are of the usual tabular habit elongated in the direction of the *a*-axis. The following forms were identified: *c* (001), *b* (010), *m* (110), *n* (120), *l* (104), *d* (102), *o* (011), *f* (113), and ϑ (124). ϑ (124), a prominent form on the crystals, is mentioned by Hintze.* *m* and *n* appear as narrow faces and did not give images. They were identified by their zonal relations and by appropriate measurements. The following are the results:

					Average.	Calculated.
c ∧ *l*	001	∧	104	8	22° 17′	22° 20′
l ∧ *d*	104	∧	102	8	17° 3½′	17° 4½′
c ∧ *o*	001	∧	011	3	52° 2′	52° 0′
c ∧ *f*	001	∧	113	3	34° 50′	34° 46½′
c ∧ ϑ	001	∧	124	6	37° 16′	38° 26½′
ϑ ∧ ϑ	124	∧	$\bar{1}24$	4	38° 11½′	38° 7′

In conclusion the writer wishes to thank Prof. A. J. Moses for suggestions in the preparation of this paper.

* Hintze, Zeitschr. f. Kryst., vol. xi, 232, 1885.

Mineralogical Laboratory, Columbia University,
New York, January, 1901.

Art. V.—*A New Solution for the Copper Voltameter;* by William K. Shepard.

The importance of the convenient and accurate method of measuring electric currents by the voltameter depends very largely upon the construction of a voltameter which admits of high current densities.

The silver voltameter gives results of a high degree of accuracy, but is not conveniently used except for small currents; the copper voltameter, however, from the cheapness of its materials, finds employment in the laboratory for the measurement of comparatively large currents.

As ordinarily used, the copper voltameter is subject to irregularities due to the solvent effect of the solution in some cases and the oxidation of the copper in others. The voltameter solution recently investigated by the writer commends itself by the facts that these irregularities are avoided and that approximately twice the current density permissible with solutions hitherto in use may be employed without loss of accuracy, thus allowing large currents to be measured without inconveniently increasing the size of the electrolytic cell.

Many different solutions for the voltameter have been recommended by various experimenters. Gray,* using a copper sulphate solution of density 1·15 to 1·18 with one per cent free sulphuric acid, found that the highest current density desirable was ·02 ampères per square centimeter of cathode surface.

Vanni† observed that a copper sulphate solution of density 1·12 with one per cent free sulphuric acid dissolved copper and therefore gave indications always too small. With an increase of the current density the deduced electro-chemical equivalent of the copper increased. A solution neutralized with copper hydrate, on the contrary, yielded results in constant excess, probably on account of the oxidization of the copper. By adding to a liter of the normal solution one half a gram of a solution which contained one per cent sulphuric acid, he found neither a gain nor a loss in the weight of a piece of copper immersed in it. With this solution he successfully used a current density of ·011 $\frac{\text{amp}}{\text{cm}^2}$, but no experiments seem to have been made to determine the limit.

Oettel‡ obtained smaller deposits of copper from copper sulphate solutions than Faraday's law demands resulting from

* Phil. Mag., xxii, p. 289, 1886.

† Wied. Annal., x, p. 214, 1891 and Phil. Mag., xxv, p. 179, 1888.

‡ Chemische Zeitung, p. 543, 1893.

the formation of oxygen compounds such as HSO_4. By the addition of alcohol these losses were avoided. He advised as the best solution :

150	gms.	$CuSO_4$
50	"	H_2SO_4
50	"	Alcohol
1000	"	H_2O

Beach* investigated the use of copper nitrate in the voltameter. His solution after neutralization had a density of about 1·53 and contained one drop of a saturated solution of NH_4Cl to 100cc. of the nitrate. The NH_4Cl was added to prevent the oxidization and consequent excess of deposit which occurs when a neutral solution is used alone. He found that he could use a much higher current density with this solution than with the copper sulphate solutions commonly used. But as copper nitrate is relatively expensive in comparison with the sulphate, it is not so well suited for general laboratory use.

It seemed to the writer of interest to attempt the use of a neutral solution of the sulphate in the same manner, with the aim of increasing the allowable current density. The solution was prepared as follows: A saturated solution of copper sulphate was boiled for a short time to expel the air and then kept at 100° C. for about an hour in contact with metallic copper in order to neutralize the solution. The density was then about 1·20. A very small amount of NH_4Cl was added, about ·05 of one per cent.

Two voltameters were used in the investigation. They were connected in series in order to see how the different solutions would agree when using exactly the same current. Each voltameter consisted of three anode and two cathode plates, the cathode plates being placed alternately between the anodes at distances of about 2 centimeters. The plates were 10·5x19cm., of which a working cathode surface of about 600cm^2 was employed. The voltameters were used in battery jars 20cm. high and 15cm. in diameter.

The method used in the preparation of the cathode plates was that given by Gray.† The edges and corners were well rounded and the plates polished with sand paper. They were next placed in water slightly acidulated with sulphuric acid for a short time to remove any trace of oxide, rinsed in clean water, dried with filter paper and then over a gas flame. After copper had been deposited, the plates were not exposed to the air for a time longer than absolutely necessary before the copper sulphate solution had been completely washed off. The reason

* This Journal, xlvi, p. 81, 1893.
† Phil. Mag., xxii, 1886.

for this is that a copper plate oxidizes rapidly when wet with a solution of neutral copper sulphate and exposed to the air. This was accomplished by removing the voltameter plates as a whole from the solution and dipping at once into water containing a few drops of sulphuric acid. They were then rinsed in clean water, dried with filter paper and over a flame.

Gray's solution was first tried for comparison. Very good deposits were obtained using a current density up to about ·03 $\frac{\text{ampères}}{\text{cm}^2}$; but the deposits would sometimes differ as much as one per cent in the two voltameters.

Oettel's solution gave fine deposits for low current densities. When, however, the current density was increased the plates blackened badly and copper was found in the form of powder on the bottom of the jars. The highest current density permissible with this solution was ·02 $\frac{\text{ampères}}{\text{cm}^2}$.

Then the solution with NH_4Cl prepared as above was investigated in the same manner. For low current densities it gave as good results as had been obtained with either Gray's or Oettel's solution, but, in contradistinction to these, the results continued to be satisfactory when these limits were widely surpassed. With a current of 20 ampères the density was increased, by raising the plates so as to lessen the immersed surfaces to a value even more than ·05 $\frac{\text{ampères}}{\text{cm}^2}$. Notwithstanding this very material increase in the demands upon the voltameter, the deposits still remained perfectly satisfactory. With 30 ampères and a current density of ·045 $\frac{\text{ampères}}{\text{cm}^2}$ the solution still gave results differing by less than one per cent.

The voltameters were then filled, one with Gray's or Oettel's solution and the other with the new solution. When employed for low current densities the solutions in all cases gave deposits agreeing within the limits of error imposed by the methods employed.

With regard to the constancy of the apparent electro-chemical equivalent when a high current density was used with this solution, no exact statement can be made, as the absolute measurement of the current was not attempted. In the first part of this investigation a Weston ampère-meter was included in the circuit, the error of which the writer has reason to believe was less than one per cent. Assuming the indications of this instrument to give the true values of the current, the electro-chemical equivalent obtained from the new solution was fairly constant.

The results are not given, as different values of the current being used they included the errors of the instrument.

Having now performed these preliminary experiments showing that the solution could be employed for large current densities without loss of accuracy and having obtained a fair idea of the working of the solution, experiments were begun with the aim of eliminating the error of the instrument.

Another Weston ampère-meter was obtained which read only to 15 ampères, each ampère division being divided into ten parts. So that with this instrument the current could be measured with an error in the reading of less than $\frac{1}{10}$th of an ampère. The instrument was not assumed to be correct, but after the experiments had been finished the results were averaged, and taking the electro-chemical equivalent of copper to be ·000329 $\frac{\text{gm.}}{\text{amp. sec.}}$ the true value of the current at the division used on the instrument was obtained.

Only one point on the ampère-meter was used, namely, the one which gave the nearest value to 15 ampères. Thus with the same division and changing the current density by raising the immersed surfaces of the voltameter plates, the error of the instrument was eliminated.

From what has just been said, it will be plain that the results given below are not presented as determinations of the electro-chemical equivalent of copper; the experimental data are reduced to that form simply for convenience in comparing them.

The current was obtained from a storage battery of 50 cells, and was kept constant by means of a copper sulphate resistance which could be varied at will by varying the distance between the copper plates.

An auxiliary circuit was arranged whose resistance was equal to that of the two voltameters. The current was thrown by means of a switch first through the auxiliary circuit to the ampère-meter and resistances included in the circuit. These were allowed to heat up until everything became constant and the resistance adjusted so as to give the desired reading of the ampère-meter. Then the current was thrown through the voltameters and assumed the desired value instantly.

The duration of an experiment was 20 minutes, so that a deposit of about 6 grams was obtained. This deposit showed no oxidization even up to the highest current density used which was greater than ·07 $\frac{\text{amp.}}{\text{cm}^2}$.

The results are arranged in series according to their respective current densities, as follows:

SERIES I.

Current Density = ·02 $\frac{\text{ampères}}{\text{cm}^2}$

No.	Equivalent × 10^7.
1	3287·2
2	3295·0
3	3288·4
4	3288·9
5	3292·8
6	3297·2
7	3286·8
8	3288·4
9	3293·9
10	3289·4
11	3287·2
12	3293·4

The mean of these values is 3290·7 with a probable error of ±2·4 for a single observation.

SERIES II.

Current Density ·03 $\frac{\text{amp}}{\text{cm}^2}$

No.	Equivalent × 10^7.
1	3288·4
2	3291·7
3	3296·7
4	3291·7
5	3292·8
6	3288·3
7	3295·5
8	3295·9
9	3294·4
10	3287·2
11	3288·4
12	3288·9

The mean of these values is 3291·7 with a probable error of ±2·3 for a single observation.

SERIES III.

Current Density ·04 $\frac{\text{amp}}{\text{cm}^2}$

No.	Equivalent × 10^7.
1	3287·8
2	3294·4
3	3287·2
4	3284·5
5	3283·9
6	3283·4
7	3296·7
8	3295·0
9	3292·2
10	3295·5
11	3296·1
12	3296·7

The mean of these values is 3291·1 with a probable error of ±3·6 for a single observation.

SERIES IV.

Current Density ·05 $\frac{\text{amp}}{\text{cm}^2}$

No.	Equivalent × 10^7.
1	3286·2
2	3286·2
3	3290·5
4	3293·4
5	3288·4
6	3286·8
7	3297·2
8	3292·8
9	3285·5
10	3287·2
11	3286·8
12	3293·4

The mean of this series is 3289·5 with a probable error of ±2·6 for a single observation.

SERIES V.

Current Density ·06 $\frac{\text{amp}}{\text{cm}^2}$

No.	Equivalent × 10^7.
1	3288·4
2	3294·4
3	3287·2
4	3290·0
5	3292·8
6	3290·5
7	3291·7
8	3295·0
9	3283·9
10	3287·2
11	3287·2
12	3291·1

The mean of these values is 3290·0 with a probable error of ±2·2 for a single observation.

SERIES VI.

Current Density ·07 $\frac{\text{amp}}{\text{cm}^2}$

No.	Equivalent × 10^7.
1	3291·7
2	3288·9
3	3291·1
4	3286·2
5	3290·5
6	3290·0
7	3287·2
8	3286·2
9	3290·5
10	3292·8
11	3286·2
12	3282·8
13	3291·7
14	3287·2
15	3292·2
16	3288·9

The mean of these values is 3289·0 with a probable error of ±1·9 for a single observation.

The results are arranged for comparison in the following table:

Series.	Current Density.	Mean.	Prob. Error of Mean.
I	·02	3290·7	±0·7
II	·03	3291·7	±0·7
III	·04	3291·1	±1·0
IV	·05	3289·5	±0·7
V	·06	3290·0	±0·6
VI	·07	3289·0	±0·6

These results show no dependence upon the current density. In fact, series VI, which differs most from the others, could be slightly increased for the following reason. The day after this series was taken the watch which had been used to measure the time was rated with a clock and found to be gaining at the rate of 2 seconds an hour when lying at the side of the ampère-meter. This was doubtless caused by the magnetic field of the ampère-meter, as the watch at other times was very correct.

If a connection were applied for this to series IV it would increase it by about one part in 1800, so that it would become 3290·6, which is in still closer agreement. During series III, IV, V, which were taken after this fact had been discovered, the watch was rated and proper connections were applied. But as the watch had not been rated during series I, II and VI, the corrections cannot be applied to them.

It is also proper to observe that although the current density was widely varied there is no loss of accuracy, as is shown by the probable errors of a single observation in the different series.

For current densities of ·05 $\frac{\text{amp}}{\text{cm}^2}$ or greater the solution was found to heat a little during the first experiment. Results which were obtained during the rise in temperature of the solution were always slightly greater than those obtained after the solution had become warm and at a uniform temperature throughout. The unequal temperature of the solution may be avoided by stirring or by making a preliminary experiment to warm up the solution. The best way was found to heat the solution by means of a flame to a temperature of about 35 or 40° C. before making an experiment. The deposits were then found to be very satisfactory even up to a current density of over ·07 $\frac{\text{amp}}{\text{cm}^2}$ and the resulting values of the equivalent to agree closely with those obtained with the low current densities.

The results given in series III, IV, V and VI were obtained with the solution at a temperature from 35° to 40° C., while series I and II were obtained with the solution at the temperature of the room, about 20° C. We see therefore that the temperature from 20° to 40° C. has practically no influence upon the results given by the solution; but that any *inequality* in the temperature of the solution will cause slight errors and therefore should be carefully avoided.

The same solution was used throughout the second part of this investigation. Perhaps fresh solutions would have given more consistent results, but certainly no large error is introduced by the repeated use of the solution.

We may collect the results with this solution as follows:

The weight of copper deposited is practically independent of the temperature between 20° and 40° C.

The results are independent of the current density within the limits given.

The solution may be used a large number of times.

The solution may be used with a current density two or three times as great as that permissible with others commonly in use, so that to measure a given current a considerably smaller voltameter may be employed than with the older solutions.

Current-measuring instruments may be calibrated by its means with an error of only about one-tenth of one per cent.

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ART. VI. — *The Thermo-magnetic and Galvano-magnetic Effects in Tellurium;* by MORTON GITHENS LLOYD, Ph.D.

THE investigations here described were begun with the idea of measuring all of the thermo-magnetic and galvano-magnetic effects in the same specimen of a non-metal, tellurium being the substance chosen. It has heretofore been investigated for only two of the transversal effects. Satisfactory numerical values of the magnitude of most of these effects have not yet been obtained, owing to the difficulties involved in their measurement, but as the work must be interrupted for some time, it is thought best to publish the qualitative results at once.

If a conducting plate carrying an electric current be placed in a magnetic field perpendicular to the lines of force, the following galvano-magnetic effects have been observed.

1. A difference of electric potential is produced between the edges of the plate, perpendicular to the direction of the current and of the magnetic field. (Hall effect.)
2. A difference of temperature is produced between the same points.
3. A change of resistance occurs. (Longitudinal Hall effect.)
4. A difference of temperature is produced in the direction of the current.*

If a flow of heat replace the primary electric current, four analogous thermo-magnetic effects are observed.

1. A difference of electric potential between the edges of the plate.
2. Rotation of the isothermal lines or a difference of temperature between the same points.
3. A change of conductivity for heat.
4. A difference of potential in the direction of the heat-flow. (Longitudinal thermo-magnetic effect.)

The transversal effects are reversed in direction when either the magnetic field, or the primary current of heat or electricity, is reversed in direction; but the longitudinal effects are independent of the direction of the field.

It has already been proposed† to call the galvano-magnetic temperature-difference, the thermo-magnetic temperature-difference, and the thermo-magnetic potential-difference by the respective names, Ettingshausen effect, Leduc effect and Nernst effect. Most of these effects were first observed in bismuth, and some of them only in bismuth. The change of conduc-

* Nernst, Wied. Ann., xxxi, p. 784, 1887.

† Thesis: The Transversal Thermo-magnetic Effect in Bismuth, M. G. Lloyd, Philadelphia, 1900; Beiblätter, 24, p. 1014.

tivity for heat was first announced by Righi* and shortly afterward by Leduc.† The Leduc effect has been observed by Leduc,† Righi,‡ and van Everdingen.§ The Nernst effect, discovered by von Ettingshausen and Nernst,‖ has been observed by van Everdingen, Yamaguchi,¶ Moreau** and the writer, these observations covering a number of metals. The Ettingshausen effect was observed by its discoverer†† in bismuth, antimony and tellurium, and was included in van Everdingen's observations on bismuth. The longitudinal thermo-magnetic effect has been observed in bismuth by von Ettingshausen and Nernst, van Everdingen,‡‡ and Lownds.§§

Chemically pure tellurium was obtained from Eimer and Amend, and cast into the form of a plate, $6{\cdot}7^{cm}$ long, $2{\cdot}5^{cm}$ wide and $0{\cdot}1^{cm}$ thick, with two lugs projecting from the middle of the lateral edges. Six thermo-electric couples of copper and German silver wire made electric connection with the plate; one to each of the lugs, the other four along the center line of the plate, separated by distances of 15, 13, 18^{mm}. These couples served to determine the temperature at the six points and thus the temperature-gradient, and in addition could be used to determine the difference of potential between any two points. The ends of the tellurium plate were pressed by springs against projections from two brass tubes, through which steam and cold water, respectively, could be passed. The whole was mounted on a wooden frame, and suspended between the poles of a powerful electro-magnet. The pole-faces were $6{\cdot}3^{cm}$ square and $1{\cdot}3^{cm}$ apart, and the magnetic field between them practically uniform. The strength of field was determined from the resistance of a calibrated bismuth spiral which was also attached to the wooden frame. When sending an electric current through the plate, cold water flowed through both brass tubes, to which the lead-wires were attached. Differences of potential were measured by comparison with a standard Clark cell, using the potentiometer. A very sensitive astatic reflecting Thomson galvanometer was used as a current-indicator.

The electromotive force, E, in microvolts, of a thermo-electric circuit of copper and German silver, one junction of

* Rend. Acc. Lincei, iii, p. 481, 1887; Beiblätter, 11, p. 670.
† Comptes Rendus, civ, p. 1783, 1887.
‡ Rend. Acc. Lincei, iii, p. 6, 1887.
§ Proc. Royal Acad. Sci. of Amsterdam, i, p. 72, 1898; Comm. from Leiden, No. 42.
‖ Anz. d. kais. Akad. Wien, xiii, p. 114, 1886; Wied. Ann., xxix, p. 343.
¶ Ann. d. Physik, i, p. 214, 1900.
** Journal de Physique ix, p. 497, 1900.
†† Wied. Ann., xxxi, p. 737, 1887.
‡‡ Ann. d. Physik, iv, p. 776, 1901.
§§ Leiden Comm., No 48; Proc. R. A. S. A., Mar. 25, 1899.

which is at 25° C. and the other at T°, has been found by Dr. H. C. Richards to be

$$E = 15{\cdot}20\,(T - 25) + 0{\cdot}0272\,(T - 25)^2.$$

One of the couples used in this work was tested between 0° and 100° and found to agree with the formula, which has been used in determining temperatures.

The plate was insulated and protected from air-currents as well as possible by the use of mica, asbestos, cotton, etc.

Ettingshausen effect. — If the primary current flow from right to left, and the lines of magnetic force are directed away from the observer, the upper edge of the plate is cooled and the lower warmed. This is in the same direction as in bismuth. The effect was measured by passing current through the plate between the two tubes, and observing the temperatures at the edges of the plate for both directions of the field, giving time in each case for temperatures to become constant. A series of readings was taken, reversing field each time, in order to eliminate any error due to the gradual change in temperature of the whole plate. Readings in zero field were not used in the calculations. They showed, however, that the effect was not symmetrical, i. e., the change for one direction of the field was not the same as for the opposite direction of the field; starting with zero field in both cases. The coefficient of the Ettingshausen effect, P, is defined by the equation

$$T = PH\frac{C}{t}$$

where T is the difference in temperature produced, by a change of field H, between the edges of a plate of thickness t when traversed by a current C. Temperatures are measured in Centigrade degrees; other quantities in C.G.S. electromagnetic units. The values of P observed ranged between 0·00014 and 0·00029 for fields up to 5500 gausses, at a temperature of about 65°. The high resistance of tellurium causes a correspondingly large generation of heat and the temperature of the interior is considerably higher than that of the surroundings. The flow of heat from the center of the plate to the edges (cooled by water flowing through the tubes) will produce a Leduc effect which may interfere with the measurements of the Ettingshausen effect. In this case the measurements were made at the center of the plate, where the temperature-gradient may be assumed zero.

Hall effect.—If the primary current flow from right to left, and the lines of force are directed away from the observer, the upper edge is at the lower potential. This direction coincides with the results of other observers and is usually considered as

positive. It is in the opposite direction in bismuth. To determine the Hall effect, the difference of potential was measured between the copper wires connected to opposite edges of the plate. This P.D. includes the thermo-effect due to the two points of contact not being at the same temperature. If the temperature remained constant, the thermo-effect could be eliminated by taking readings for both directions of the field. But the temperatures are not constant, the Ettingshausen effect producing a change whenever the field is reversed, and this must be allowed for. It was found in this case to affect the second significant figure by one unit only and hence is neglected. The coefficient of the Hall effect, R, is defined by the equation

$$E = RH\frac{C}{t}.$$

In a field of strength 4,000 gausses, the value of R found was 430 C.G.S. at a temperature of 65°.

Change of resistance—The resistance was determined by the difference of potential of two points between which a current was flowing. The current and P.D. were measured with Weston ammeter and voltmeter. The accuracy of the observations would serve to determine a change in resistance of one-half of one per cent. No change was found in fields up to 5,500 gausses. Other observations* on tellurium show an increase in resistance less than this.

Leduc effect.—If the heat flow be from right to left and the lines of force are directed away from the observer, the upper edge of the plate is cooled. The direction in bismuth is the reverse of this. The coefficient of the Leduc effect, S, is defined by the equation

$$T = Sb H\frac{d\tau}{d\lambda}$$

where b is the breadth of the plate and $\frac{d\tau}{d\lambda}$ the longitudinal temperature-gradient. Values of S between 0·000002 and 0·000005 were obtained at temperatures between 30° and 38° in fields of strengths from 2,500 to 5,200 gausses. The coefficient appears to increase with the temperature.

Nernst effect.—If the heat flow be from right to left, and the lines of magnetic force are directed away from the observer, the upper edge is at lower potential. In bismuth the direction is the same. The coefficient of Nernst effect, Q, is defined by the equation

$$E = Qb H\frac{d\tau}{d\lambda}.$$

* Goldhammer, Wied. Ann., xxxi, p. 360, 1887.

The difference of potential between the copper leads connected to opposite edges of the plate is the resultant of the Nernst effect and the thermo-electric effect at the two junctions. Since the two junctions are in general at slightly different temperatures, they do not balance one another. If their temperatures were constant, the thermo-electric effect could be eliminated by taking readings for both directions of the magnetic field; for in one case the Nernst effect would be added to it and in the other case subtracted. Owing to the Leduc effect, the temperatures do not remain constant, but are altered by reversing the field.

Let E=Nernst effect; V and V′=the observed P.D.'s for two directions of the field; ϵ=thermo-electric power for copper and tellurium; t_1 and t_2=the temperatures of the two junctions for one direction of the field, t_1' and t_2' for the other;

T=Leduc effect=$\frac{1}{2}(t_1-t_1'+t_2'-t_2')$. Then

$$V=\epsilon(t_1-t_2)+E$$
$$V'=\epsilon(t_1'-t_2')-E$$

whence

$$E=\frac{V-V'}{2}-\epsilon T.$$

It is thus seen that the observed values of V must be corrected for the Leduc effect. In bismuth this correction was found negligible; in tellurium it is not so, owing to the enormous thermo-electric power of copper and tellurium, but assumes a magnitude of the same order as the Nernst effect. An accurate determination of the Nernst effect requires an accurate knowledge not only of one value of this thermo-electric power, but also of its variation with temperature and with strength of field. The values of ϵ observed are slightly over 600 microvolts, whereas the value usually given is about 500.

Observations of the Nernst effect give a value of Q=0·36 at 33° in a field of about 3,000 gausses. As in the case of the Hall effect the constant is larger than has been observed in any metal.

Change of heat-conductivity.—The conductivity is lessened in the magnetic field. The relative conductivities were calculated from observations of temperature at four points along the center line of the plate, assuming the thickness to be uniform and the surface-conductivity to be constant. Neither of these conditions is fulfilled, and hence the results are only approximate. The ratio of conductivity in a field of strength 4700 gausses to that in zero field was found to be 0·9.

Longitudinal thermo-magnetic effect.—The warm end of the

plate is at the higher potential. This direction is the same as Lownds* has found in bismuth at ordinary temperatures.

Two suggestions have been made† which might explain the origin of the longitudinal effects. One is, that the thermo-electric-power is altered in a magnetic field. Lownds has demonstrated that the effect observed by him cannot be so explained. The other suggestion is, that owing to a change in heat-conductivity, the temperatures at the junctions are changed, thus changing the E.M.F. in circuit. This explanation is plausible where the effect was measured by compensating the E.M.F. in zero field, and observing the change produced by the field. Lownds does not mention whether he made any test of this possibility, but in one of his experiments at least (p. 779) it is evident that the E.M.F. could not have had this origin.

The longitudinal effect has been observed in bismuth also by van Everdingen,‡ and found to vary with the strength of field according to the same law as the variation of resistance.

In my own experiments the temperatures at the junctions were observed in the given field as well as in zero-field, and allowance made for the change. Theory§ indicates that longitudinal effects should be proportional to the square of the strength of field, and independent of its direction. I have noticed that in every case the effect was greater for one direction than for the other. The mean value for a field strength of 2750 gausses, mean temp. = 39°, difference of temp. = 19°, was 1050 microvolts.

If we regard the transversal differences of temperature and potential as due to the transfer of heat and electricity respectively across the plate, we notice that in tellurium the transfer of electricity is always in the same direction as the transfer of heat. That is, the edge which is raised in potential is also raised in temperature. Moreover, to produce the same effects with a current of electricity as with a current of heat, the direction of flow must be the same for both. For example, the edge which is warmed by the Leduc effect has its potential increased by the simultaneous Nernst effect. And to warm the same edge by the Ettingshausen effect as by the Leduc effect, the primary currents of electricity and heat must have the same direction.

In bismuth, the reverse is the case, the heat and electricity being transferred in opposite directions. Thus the edge which is warmed by the Leduc effect has its potential lowered by the simultaneous Nernst effect. And to warm that same edge by

* Ann. d. Phys., iv, p. 776, 1901.
† Grimaldi, Nuov. Cim. (3), xxii, p. 5, 1887; Goldhammer, *l. c.*
‡ Leiden Comm., No. 48, 1899. § Drude, Ann. d. Physik, iii, p. 377, 1900.

the Ettingshausen effect would require a primary electric current in the direction opposite to the heat flow producing the Leduc effect. These facts are of especial interest in connection with Liebenow's* theory of thermo-electric currents, in which he arrives at the conclusion that in metals heat always flows with the *negative* electricity, whereas in non-metals it accompanies the *positive* electricity. If this relation between the directions be a general one, a knowledge of the direction of any one of the four transversal effects would be sufficient to determine the direction of the other three. Of the eleven elements examined by Nernst† for the Nernst effect, six (Bi, Sb, Ni, Fe, Zn, Pb) bear out this relation with the Hall effect, if we regard antimony as a non-metal. Of the other five, three (Cu, Ag, Sn) showed such a small effect that they may be regarded as doubtful. The two notable exceptions are carbon and cobalt. It has been already noted by several writers‡ that cobalt occupies an anomalous position as regards its Hall-constant, and it may be that the Ettingshausen effect is large enough in this metal to entirely vitiate the measurements which have been made of its Hall-effect, even to changing the sign. In this regard it is to be noted that the thermo-electric-power is large between cobalt and copper, the metal usually used for lead-wires. Or the measurement of Nernst effect may have been equally influenced by Leduc effect. Morean (*l. c.*) however, found an opposite direction for the Nernst effect in cobalt, which would make it agree with the general rule. The direction of the Ettingshausen effect in antimony is in harmony with the other effects.

This idea comes in conflict, however, with the "Electronentheorie" of Drude,§ which requires that the Ettingshausen effect be in the same direction in all metals. For the above relation to hold, the Hall-effect must also be in the same direction in all metals, which we know is not the fact. In the only three substances yet examined, bismuth, tellurium and antimony, the direction of the Ettingshausen effect has been found the same.

I summarize the constants for the four transversal effects.

		H_{max}	t
Ettingshausen	$P = 0{\cdot}0002$	5500	65°
Nernst	$Q = 0{\cdot}36$	3000	33°
Hall	$R = 430{\cdot}$	4000	65°
Leduc	$S = 0{\cdot}000004$	5200	30–38

* Wied Ann., lxviii, p. 316, 1899. † Wied. Ann., xxxi, p. 760, 1887.
‡ Von Ettingshausen u. Nernst, Wiener Berichte, xciv, p. 560, 1886; J. C., Beattie, Proc. Royal Soc. Edinburgh, xx, p. 481, 1895; Drude, Ann. d. Phys., iii, p. 392, 1900. § Ann. d. Physik, iii, p. 369, 1900.

Laboratory of Physics,
University of Pennsylvania,
June 1, 1901.

ART. VII.—*Additions to the Avifauna of the Bermudas with diagnoses of two new Subspecies;* by A. HYATT VERRILL.

DURING a recent collecting trip to the Bermudas, from March 10th to May 9th, 16 species of birds were observed that appear not to have been previously recorded:

Phaëton æthereus. Red-billed Tropic-bird. Several were seen on Harrington Sound in April.

Larus glaucus. Glaucous Gull. A large flock remained some time. Seen about the islets in Harrington Sound early in March. Were regarded as something new by the inhabitants.

Melanerpes Carolinus. Red-bellied Woodpecker, Chab. Seen April 8th, on a Pride of India tree.

Passer montanus. European Tree-sparrow. Locally common in Paget Parish. Naturalized; resident. Probably introduced with the English Sparrow.

Carduelis carduelis. European Goldfinch. Abundant on the southern and eastern parts of the islands, especially about Hungry Bay. Accidentally introduced about 1885, from a wreck. Previously recorded by Reid as an escaped cage-bird.

Spinus tristis. American Goldfinch. Resident. Not uncommon. Intentionally introduced about 1896, near Hungry Bay.

Spizella monticola. Tree-sparrow. A flock was seen several times at Hungry Bay during the latter part of March.

Sitta Carolinensis. White-breasted Nuthatch. Seen April 14th to 30th, on cedars at Harrington House.

Dendroica Pennsylvanica. Chestnut-sided Warbler.

Dendroica striata. Black-poll Warbler.

Dendroica Blackburniæ. Blackburnian Warbler. The last three were seen in flocks of other migrants, March 12th to 15th, at Hamilton.

Saxicola œnanthe. Wheatear. Introduced recently near St. Georges. Appears to be perfectly naturalized. Previously recorded by Reid as a rare migrant.

Mimus polyglottus. Mocking Bird. Resident. Introduced about 1892, at Bailey Bay. Not uncommon at Walsingham and Paynter's Vale. Appears to be now naturalized.

The following four species were identified from the local collection in the Public Library at Hamilton: Orchard Oriole; Thrasher or Brown Thrush; Blue Jay; Red-shouldered Hawk.

The abundant resident Ground Dove proves to be the Bahama subspecies (*Columbigallina passerina Bahamensis*). It always has a black bill.

The resident Bluebird is decidedly larger and brighter colored than the true *sialis*. It is a new subspecies.

Sialia sialis Bermudensis A. H. Verrill.

Blue of the upper parts of male brilliant purplish azure, a little brighter on rump; chin light blue. Breast, sides and flanks deep purplish-cinnamon, much darker and richer than in North American specimens. Female more brownish with brighter rump and back than in the true *sialis*. Edge of wing, at carpal joint, distinctly pure white.

Length, 6·75 to 7·5 inches; wing, 4 to 4·25; tail, 2·75 to 3·25. Nest usually built in crevices and holes of cliffs; eggs usually pure white, rarely tinged with greenish-blue.

The resident cardinal bird of Bermuda also differs as a subspecies, from the American forms:

Cardinalis cardinalis Somersii A. H. Verrill.

Adult male: Lower parts brilliant orange-vermillion, brighter and more orange than in *C. cardinalis*. Upper parts are also clearer and brighter, deep lake-red, with scarcely any gray on tips of feathers. Vermillion of cheeks and crest brighter and clearly defined. Bill deep scarlet. Female lighter than in *cardinalis*, especially below; breast buffy yellow; belly almost pure white; upper parts clear ashy gray; crest and ear-coverts strongly tinged with red; wings and tail nearly as in the male.

Length, 8·75 inches; wing, 3·75; tail, 4·75; culmen, 0·80.

ART. VIII.—*The Induced Alternating Current Discharge studied with Reference to its Spectrum and especially the Ultra-Violet Spectrum;* by A. W. WRIGHT and E. S. DOWNS.

IN some experiments made in this laboratory a few years ago, in photographing the spectrum of an induced alternating current discharge, produced under special conditions between copper terminals, a plate was obtained which contained a very great number of lines. The primary purpose of this investigation was to locate these lines and if possible discover their origin, and secondly to study this peculiar form of discharge when produced on a very large scale. Spottiswoode* was among the first to give an account of this mode of exciting an induction coil by the direct application of an alternating machine, without the intervention of a contact breaker or the use of a condenser. In the Proceedings of the Royal Society† he points out some peculiarities of the discharge which he noted.

In our experiments the induction coil was used without a contact breaker or condenser. It had four hundred and twelve turns of wire about 3^{mm} in diameter for its primary, and a secondary of about $25{\cdot}5^{cm}$ in length, consisting of about fifty thousand turns of wire $0{\cdot}3^{mm}$ in diameter. In the core of the primary, which was $35{\cdot}5^{cm}$ long and $3{\cdot}5^{cm}$ in diameter, there were nearly a thousand soft iron wires carefully annealed and insulated with shellac. As a result of having such large wire for its secondary, the current was very large, and the potential as determined by the length of the spark was in the neighborhood of 120,000 volts. The current was supplied to the coil by a Siemens alternating current dynamo of about five horse power which was driven by a gas engine, and whose magnets were excited by a small dynamo using approximately three horse power.

With the terminals arranged horizontally the discharge was exceedingly intense and vigorous, being accompanied with a loud singing noise. It consisted of a light nebulous flame of a whitish color, with a slight tinge of yellow or green, rising gradually from the terminals and meeting at the center, where the color changes to a reddish. The flame appeared to the eye to be continuous, but, when observed in a rotating mirror or photographed on a swiftly moving plate, the alternate discharges were plainly discriminated. About and close to the terminals the bluish-purple flame, caused by the nitrogen of the air was plainly seen. The spark would leap across an interval of about $3{\cdot}5^{cm}$, and when the discharge was once started, the terminals could be drawn apart for as much as 20^{cm}

* Phil. Mag., Nov. 1879. † Vol. xxx, p. 173.

or 25^{cm} without extinguishing the flame, presenting a striking and beautiful spectacle.

It may be of interest here, in view of the peculiar character of the discharge, to give the results of some experiments which were made a few years ago in this laboratory to determine the time and mode of its formation. A camera was arranged so that the discharge, just as it was forming, could be photographed upon a rapidly moving plate. At the same time the image of a spark from a tuning fork whose point dipped in mercury was adjusted so as to fall upon the plate side by side with that of the discharge. The photographs show that the spark passes directly across at first. As each spark has a tendency to follow its predecessor and the air becomes heated causing an upward current, the path of the discharge rises upward little by little until it reaches its permanent condition. From the period of the tuning fork it was calculated that about one-tenth of a second was required for this.

In the Chemical News* Crookes has an article on this flame in which he states that it consists chiefly of nitrogen burning with the formation of nitrous and nitric acids, and that it shows no lines, but that the spectrum is faint and continuous. It is more probable though that the conditions here are similar to those in a tube from which a portion of the air has been exhausted. Owing to the heat, the air within the aureola becomes rarified and partially conducting. The luminosity is caused by the air being heated and electrified. Stratifications can be seen and photographs show them distinctly somewhat as they are shown in a vacuum tube.

An examination of the spectrum with terminals of several different metals, made by means of an ordinary prism spectroscope, shows in all cases, and as the most prominent feature, a continuous background which is very bright in the red, yellow, and green, but gradually decreases in intensity until it fades away in the violet. The yellow sodium lines are always present, due to particles in the air or impurities of the electrodes. Generally a few of the stronger lines, which are due to the metal of the electrodes and are ordinarily seen in its flame spectrum, appear and others which come out only occasionally. With zinc terminals and also with those of aluminum, the flame is yellowish in color but has a peculiar bluish-green core which is very intense, extending in streaks throughout the flame. The discharge from electrodes of soft iron which are small in diameter presents a beautiful spectacle, inasmuch as the iron, because of its large resistance, becomes highly incandescent, and bursts into a brilliant combustion, throwing off luminous particles in all directions. A banded structure from about wave length

* June 17, 1892.

4247 to about wave length 4225 came out which appeared to be the same in the case of all the metals employed. When the coatings of a large Leyden jar were connected to the terminals of the secondary, the discharge took the form of intensely brilliant sparks following one another in such rapid succession and such energetic detonation as to cause a jagged and almost deafening roar. In general the spectra of the metals employed in the induction flame are less complete and less developed than their flame spectra, owing to the fact that they are obscured by the rather intense continuous spectrum.

For a more careful study of the spectrum than the one previously described, which was made with the naked eye, it was necessary to have recourse to photography. To obtain the photograph of this discharge a Rowland concave grating having a radius of 21·5 feet was employed. The upper half of the photographic plate was exposed to the spectrum of the sun's rays for a comparison and the lower half to that of the flame between the terminals of the metal to be studied.

The plate upon which was the spectrum which it was the primary purpose of this investigation to locate, was stained with erythrosine to make it more sensitive to the rays at the red end of the spectrum. This staining also appears to increase the sensitiveness of the plate for ultra-violet rays. These lines are in the region where the red of the first spectrum and the ultra-violet of the second overlap, and they begin abruptly at wave length 6127·32 in the red and extend down to 6269·09, or at 3063·66 in the ultra-violet, extending down to 3134·55. Inasmuch as the two spectra overlap, it was uncertain to which spectrum they belonged.

The first thing that suggested itself was that these might be due to copper from the electrodes. Very few copper lines so far down in the red are given in the very admirable tables of the British Association Report.* This fact renders it impossible to make a comparison of any significance with the lines given in this region. The number of copper lines given in the ultra-violet was much larger, but still so much smaller than the number of lines upon the plate that no comparison of any value could be made although there were a few cases of approximate coincidence.

With a view to ascertain to which spectrum the lines belonged various devices were employed. At first plates stained with cyanine were tried, and some preliminary experiments made in obtaining the solar spectrum to get the time of exposure. It was found that an exposure of eighteen minutes gave a good spectrum extending into the red far beyond the situation of the lines in question. Several plates were then exposed to the

* 1884, p. 384.

discharge for an hour and a half to secure the lines, but, as no lines were obtained, and none of the ultra-violet lines of the solar spectrum were visible, it was suspected that the staining with cyanine, while it made the plate more sensitive to the red rays, diminished the sensibility to the ultra-violet, and therefore, that probably the lines sought were in the ultra-violet.

Plates stained with erythrosine were next tried. It was found that an exposure of five minutes gave the ultra-violet spectrum of the sun's rays together with the lines in the red, in the neighborhood of the lines sought for. To obtain the lines several exposures to the discharge of an hour and a half were made and a few feeble lines obtained. The time of exposure was then increased to two hours. Upon development the lines upon the first plate tried were sharp and distinct. The wave lengths were calculated as accurately as possible by means of the comparison solar spectrum and Rowland's charts. This is first done on the supposition that they are in the lower part of the first spectrum and the result divided by two to get their true wave length in the ultra-violet of the second spectrum, since it was now regarded as almost certain that they were ultra-violet lines owing to the fact that we did not obtain them with plates stained with cyanine, which makes them more sensitive to the red rays, and on the contrary did obtain them when the plates were stained with erythrosine, which increases their sensitiveness to the ultra-violet, as was proven by exposing a dry unstained plate to the sun's rays when, although the ultra-violet lines were visible, they were exceedingly faint.

The wave lengths as calculated by means of Rowland's charts of the solar spectrum and the comparison on the plate are as follows:

3063·66	3086·48	3105·71
3063·83	3087·40	3106·02
3064·30	3089·80	3106·55
3065·04	3089·94	3109·46
3065·17	3090·24	3110·30
3066·27	3091·35	3112·17
3068·00	3091·48	3113·43
3068·31	3092·45	3114·85
3069·11	3092·84	3115·49
3070·02		
3070·52	3094·70	3117·87
3070·83	3095·41	3118·03
3072·05	3096·16	3122·70
3078·47	3096·87	3124·14
3080·06	3098·63	3130·46
3080·27	3099 53	3134·55
3081·65	3101·20	
3083·35	3102·13	
3085·25	3102·35	

In the next experiment platinum electrodes were used in order to determine whether the lines were due to copper or to the gases through which the discharge passed. This plate upon development showed exactly the same series of sharp lines. Hence they must be due to some one of the gases, or the oxides of them, which occupy the intra-polar space.

To settle the location of the lines conclusively the camera was adjusted so as to include the region in the first spectrum in which they were supposed to be. An ordinary dry plate without staining was used and an exposure of an hour given it. After the development of the plate the lines sought were seen sharp and clear, which proved conclusively that they were in the ultra-violet of the first spectrum.

The work of ascertaining to what one of the intra-polar gases, or oxides of them, the lines belonged, was next taken up. A careful comparison of the recorded lines of the hydrogen spectra did not reveal any coincidence. In the Report* of the British Association for the Advancement of Science some lines due to water vapor are given, and a comparison with the lines studied in this investigation showed that a large number of them were apparently in exact coincidence.

These lines were discovered by W. Huggins† and also by G. D. Liveing and J. Dewar‡ at almost the same time. Huggins exposed a photographic plate to the flame of hydrogen burning in air for one minute and a half and was very much surprised upon developing it to find such a strong group of lines. He traced the lines in this group from wave lengths 3062 to about 3290, the upper limit of which is about the same as that of the lines studied here and the lower limit considerably below. Upon placing a spirit lamp before the slit of the spectroscope the spectrum is essentially the same, but, as it is less intense, only the strongest lines are seen.

In their article Liveing and Dewar give the results of the study of some lines which they had obtained and noted in the spectrum of coal gas burning in oxygen when investigating the spectrum of "Compounds of Carbon with Hydrogen and Nitrogen." The group of lines which they obtained extends from wave lengths 3062 to about 3210. The same spectrum was given by the electric spark taken, without condenser, in moist hydrogen, oxygen, nitrogen, and carbonic acid gas, but it disappeared if the gas and apparatus were thoroughly dried. Hence they were led to the conclusion that the spectrum was that of water. In conclusion they were not prepared to guarantee that oxides of nitrogen from traces of air might not have something to do with some parts of the spectrum here observed.

* 1886, p. 169. † Proc. Roy. Soc., vol. xxx, p. 576.
‡ Proc. Roy. Soc, vol. xxx, p. 580.

In a second* communication to the Royal Society, "On the Spectrum of Water," Liveing and Dewar state that the spectrum which they had figured in the article just mentioned did not by any means exhaust the spectra of flames observed by them, but that it was as much as they were able at that time to trace to water as its cause. In a third† article they give the results of a very searching investigation of the spectrum of the oxy-hydrogen flame. By making long exposures they obtained photographs of the oxy-hydrogen flame, showing closely set lines from wave lengths 2268 to 4100, with traces of lines beyond those limits. The whole spectrum appeared to consist of a rythmical series of lines, the strongest of these series being the one first described.

Liveing and Dewar refer to an article‡ by M. Deslandres in which he states that the first band of the water spectrum (i. e. the group beginning at wave length about 3063) includes a series of rays which reproduce, line for line, at the same distance and with the same relative intensities, the band A of the solar spectrum; and that the second band (i. e. the group beginning at a wave length about 2811) includes a series corresponding to B, and that in the third *a* may be found to be reproduced. Liveing and Dewar were not able to make out such an exact correspondence between the lines of the water spectrum and those of A, B, and *a* as M. Deslandres' words seem to imply, but nevertheless the similarity of the grouping was very remarkable.

To study further the question whether these lines were due to water vapor, or to the effect of water vapor upon the gases occupying the intra-polar space, a plate was exposed to the discharge when it took place under special conditions, namely that the upper half of the plate should be exposed to the discharge when it took place in ordinary air and the lower half of the plate to it when it took place in air containing a large amount of moisture. For the purpose of supplying a large amount of water vapor to the air about the discharge during the exposure of the lower half of the plate, water was boiled in a glass flask, containing a cork stopper through which passed a glass tube so shaped that by its means the issuing jet of steam could be easily directed into the flame.

In this experiment the upper half of the plate was exposed for forty-five minutes to the discharge in ordinary air, and the lower half for the same length of time when steam was supplied to it. In the latter case the time during which the light actually fell upon the slit of the spectroscope was not really as

* Proc. Roy. Soc., vol. xxxiii, p. 274.
† Trans. Roy. Soc., vol. clxxix (A), p. 27.
‡ Comptes Rendus, vol. c, p. 854.

great as in the first case owing to the fact that the flame was somewhat disturbed by the jet of steam. Nevertheless, when the plate was developed, the lines upon the lower half came out much more strongly than upon the upper, the only difference being in the intensity, which shows that if the lines are not directly due to water vapor, the latter greatly facilitates the development of lines due to the several gases of the air, or combinations of these gases, probably both.

Tables of wave lengths of the different constituents of the atmosphere were next examined to see if any of the lines given coincided with the lines studied. In a note* regarding a very careful search which he made for the line spectrum of hydrogen in the oxy-hydrogen flame, Liveing states that he failed to find the slightest trace of any one of the hydrogen lines. As oxygen is a very large constituent of the air, it was very important to make a comparsion of the lines due to it, which were catalogued, with these lines. There were found, however, to be no coincidences, which indicates that none of the lines are due to oxygen.

Just before the completion of this work an article by G. Berndt appeared.† While studying the spectra of several metals, Berndt had noticed in all of them a banded spectrum extending from wave lengths 5100 to 2000, a portion of which covers the region in which the banded structure previously described was located. He concluded from his observations that the banded structure in the visible portion of the spectrum of different metals is dependent upon the presence of oxygen and also suggested that the banded spectrum in the ultra-violet is due to air. At the close of his article Berndt publishes a list of nitrogen lines obtained by an induction discharge in nitrogen free from oxygen. Upon comparing them with the lines studied in this investigation, a number of apparent coincidences were seen, making it probable that some of these lines at least were due to nitrogen.

The last experiments made were a continuation of the attempt to ascertain if possible to which one of the intra-polar gases the lines belonged. As the solar light in this region is very feeble, the light from a voltaic carbon arc was passed through bulbs containing nitrogen tetroxide, and an attempt made to secure the absorption lines due to it. The lower half of the photographic plate was exposed to the light which passed through the nitrogen tetroxide and the upper half to the light from the discharge alone to see if any of the lines coincided with the absorption lines due to the nitrogen tetroxide. Although several exposures of nearly two hours were

* Phil. Mag., vol. xxxiv, p. 371.

† Drude's Annalen der Physik, No. 4, p. 788, 1901.

made to get the absorption spectrum, the lines obtained were so feeble and so few in number that it was impossible to make a comparison of any significance in determining the coincidences with the lines investigated.

After considering the large amount of work done in the past in studying this strongest group of the so-called water spectrum and also the work done in this investigation, it seems hardly possible that the lines are due to water vapor alone, but rather that they are due to the various constituent gases of the air and combinations of them which are facilitated by the presence of water vapor. On the whole, owing to the small amount of water vapor in the air, the experiments seem to point to the conclusion that the lines of this group are due for the most part to the nitrogen of the air and its oxides.

Sloane Physical Laboratory, June 11, 1901.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Ignition-temperature of Phosphorus.*—The temperatures given in chemical literature as the point at which phosphorus takes fire in the air or in oxygen vary from 38·1 to 75°. The amount of moisture present in the air or oxygen probably has a great effect upon this temperature, as it is well known that phosphorus may be distilled in perfectly dry oxygen without ignition. F. H. Eydman, Jr. has now made a careful series of experiments with air, oxygen, and air diluted with an equal volume of carbon dioxide. These gases were used in a moist condition, in fact they were made to bubble through molten phosphorus which was under water in a test-tube. The test-tube, which contained a thermometer, was placed in a flask of water, and the latter was gradually heated until the phosphorus was ignited by the gas which bubbled through. With air the observed temperatures of ignition varied from 44·9 to 45·4°, with an average of 45°; with oxygen the mean of four closely agreeing results was 45·2; while with the mixture of air and carbon dioxide two experiments gave 45° in each case. The interesting conclusion is reached that the ignition-point of phosphorus does not vary with the concentration of the oxygen. The author intends to extend his experiments by using dry air and oxygen.—*Recueil Trav. Chim. Pays-Bas*, xix, 401. H. L. W.

2. *The Composition of "Caro's Acid."*—Baeyer and Villiger have made an investigation of this powerfully oxidizing acid, which is prepared either by treating a persulphate with concentrated sulphuric acid, by the electrolysis of rather concen-

trated sulphuric acid, or by the action of concentrated sulphuric acid on hydrogen peroxide. These chemists were unable to obtain the acid in a pure state or to prepare any salts of it, but by studying the behavior of hydrogen peroxide, Caro's acid, and persulphuric acid they found that the first substance could be determined and destroyed in the presence of the others by means of potassium permanganate, and that Caro's acid liberates iodine immediately from acidified potassium iodide solution, while with persulphuric acid this liberation is very slow. By applying these facts they were able to determine the ratio of the oxygen to the sulphuric acid liberated by the acid under investigation, and the conclusion was reached that it has the composition represented by the formula H_2SO_5. The probable structure of the acid is $\begin{matrix} H-O \\ HO-O \end{matrix}\!\!>\!SO_2$. The change from persulphuric acid to Caro's acid, which takes place gradually in solution, is as follows :

$$H_2S_2O_8+H_2O=H_2SO_5+H_2SO_4$$

Caro's acid is then gradually changed in solution to sulphuric acid and hydrogen peroxide according to the equation,

$$H_2SO_5+H_2O=H_2SO_4+H_2O_2.$$

In the presence of strong sulphuric acid the last equation is reversed to a certain extent, but the product still contains much unchanged hydrogen peroxide.—*Berichte*, xxxiv, 853. H. L. W.

3. *Vitrified Quartz.*—In a recent discourse delivered before the members of the Royal Institution in London, W. A. Shenstone exhibited the production of tubes and bulbs of fused silica. The first stage of the process consists in getting quartz into a condition in which it will not fly to pieces when heated. This is done by heating it in small fragments to about 1000° and throwing it quickly into cold water. It then becomes white and enamel-like, and after the treatment has been repeated it may be thrust suddenly into the hottest part of an oxyhydrogen flame without splintering to the slightest extent. Silica becomes hot enough to be worked only above the melting-point of platinum, and it is only the hottest part of the oxyhydrogen flame, just beyond the inner blue cone, where the temperature is sufficient for the purpose. To produce tubes and other vessels from the enamel-like silica, two fragments of it held in platinum forceps are heated and pressed together until they adhere, then other lumps are added, one at a time, until a rough rod is produced. This rod is afterwards reheated and drawn out into a finer rod about 1^{mm} in diameter. Some of these fine rods are then bound round a stout platinum wire, while soft, and heated until their sides adhere. The rough tube thus made is reheated, drawn out and, after being closed at one end, a bulb is blown in it. By applying thin rings of silica to the small bulb, heating until the silica begins to spread and blowing out, it is increased in size, and by drawing out such bulbs long tubes may be prepared. When a silica tube has been produced it may be worked in the flame as easily, though not as

inexpensively, as glass. It may be thickened by adding fresh rings of silica, and all kinds of joints can be easily made. In one respect silica is easier to work than glass. It never breaks when suddenly thrust into the flame, and the finished apparatus needs no annealing. For this work the eyes must be protected by very dark glasses.

Vitrified quartz is harder than feldspar, but less hard than chalcedony. When cut with a file it breaks like glass. Its conducting power for heat is about equal to that of glass. Its density, 2·21, is much lower than that of quartz, 2·66. It has been found that the coefficient of expansion by heat is only $\frac{1}{17}$ as great as that of platinum, and much smaller than that of any similar substance that has hitherto been studied. The substance is shown to be remarkably transparent to ultra-violet rays, hence its application to spectroscopic work will probably be important. Perhaps the most remarkable property of vitrified silica is its resistance to sudden changes of temperature. Water may be dropped upon a white hot rod of the substance, or a similarly heated tube of it may be plunged into cold water or even into liquid air without injury. It is suggested that the material will be useful in the preparation of thermometers, for instance, those in which tin is used in the place of mercury, and also for the bulbs of air-thermometers. The interesting observation has already been made that when oxygen and nitrogen (air) are heated above the melting-point of platinum in a silica tube, nitrogen peroxide is produced.—*Chem. News*, lxxxiii, 205. H. L. W.

4. *Influence of Magnetism upon Supersaturated Solutions.*—Attempts by A. DE HEMPTINNE to produce the crystallization of supersaturated solutions and supercooled fusions by exposure to a strong magnetic field were in every case failures. By indirect means it was shown that crystalline substances in saturated solution showed a distinct orientation in this field; hence it is concluded that crystallization in these cases does not depend upon the orientation of the molecules.—*Zeitschr. physikal. Chem.*, xxxvii, 223. H. L. W.

5. *The Preparation and Properties of Ammonium Cyanate.*—This salt was not obtained as a solid in a pure condition by Liebig and Wöhler, on account of its transformation into urea. WALKER and WOOD have recently succeeded in preparing this famous salt by mixing solutions of cyanic acid and ether at −17°, and also by mixing the gases diluted by air. It is a colorless salt which is readily soluble in water, and this solution gives the reactions for the cyanate and ammonium ions. Upon heating it fuses at 80°, but then becomes solid again, being changed to urea.—*Jour. Chem. Soc.*, lxxvii, 21. H. L. W.

6. *Detection of Selenium in Sulphuric Acid.*—It has been found by JOUVE that crude acetylene gas furnishes a very delicate test for selenium in sulphuric acid by precipitating it in the elementary condition. He states that a red coloration can be observed when the acid contains only one part of selenium in 100,000, while

the test with sulphurous acid is only about one-tenth as delicate. The sensitiveness of the reaction is increased, as far as the rapidity of the coloration is concerned, if the acetylene contains hydrochloric acid fumes.—*Chem. News*, lxxxiii, 243. H. L. W.

7. *Qualitative Chemical Analysis, Organic and Inorganic;* by F. Mollwo Perkin. 8vo, pp. viii, 266. London, 1901 (Longmans, Green & Co.).—This is an elementary text-book that is unusually full in respect to the explanations and chemical equations that are given, and good judgment has been used in the selection of the analytical methods that are employed. The book presents a novel feature in including a treatment not only of the more common organic acids, but also a variety of other organic substances, such as aldehydes, alcohols, acetone, glycerol, several sugars, starch, a few bases and glucosides, and about a dozen of the more important alkaloids. H. L. W.

8. *Viscosity of Argon.*—Lord Rayleigh obtained the value 1·21 for the frictional coefficient of argon at ordinary temperature. Hugo Schultze, thinking that the apparatus employed by Lord Rayleigh was not suitable for obtaining extreme accuracy, has made new determinations. Extraordinary care was taken in cleaning the glass of the apparatus and in purifying the argon. It was possible to force the argon back and forth through the glass tubes, and to measure the time of flow with accuracy. The gas was also heated in a well devised calorimeter and a much improved manometer of water in combination with mercury was employed. The relative value obtained by the author is a little larger than that obtained by Rayleigh. Tables are given of the relative values of the coefficient with reference to air. The temperatures varied from 15° C. to 183° C.—*Ann. der Physik*, No. 5, pp. 140–165. J. T.

9. *Conductivity produced in Hydrogen and Carbonic Acid Gas by the Motion of Negatively Charged Ions.*—This subject has been studied by Professor Townsend and Mr. P. J. Kirkby by the aid of the Röntgen rays, which were allowed to fall on the gases contained between two parallel plates—maintained at various differences of potential. The authors conclude that a negative ion makes 11·5 collisions per centimeter in hydrogen at 1^{mm} pressure, and 29 collisions per centimeter in carbonic acid gas at the same pressure. It was found that the mean free path of an ion is longer than the mean free path of a molecule in the following ratios:

4·8 : 1 in hydrogen.
4·6 : 1 in carbonic acid gas.
4·3 : 1 in air.

—*Phil. Mag.*, June, 1901, pp. 630–642. J. T.

10. *Electromotive Force of the Clark- and the Weston-Cell.*—An exhaustive examination of the constancy of the electromotive force of these elements has been made at the Reichsanstalt, by W. Jaeger and S. R. Lindeck. This result of their work shows that the criticisms of Cohen, in regard to an instability of

cadmium sulphate and cadmium amalgam in the proportions employed in the cells used at the Reichsanstalt, are not well founded, at least when the thirteen and twelve per cent amalgam is employed.—*Ann. der Physik*, No. 5, pp. 1–50. J. T.

11. *Electrical Flow in Gases.*—L. STARK gives a theoretical discussion of this subject in which he shows under what conditions Ohm's law does not apply to electrical discharges in Plucker tables. The streaming and the phenomena of stratification depend upon the rate of arrival and departure of ions—also upon the amount of ionization and mobilization. Ohm's law holds for that portion of the discharge in which the ionization remains constant. In general there are only portions where this is true. In the neighborhood of the electrodes on account of the transport of free ions by the streaming the ionization is lowered. This happens especially at the cathode. In metallic conductors the force lines coincide with the stream lines. This is not true in the case of electrical discharges in gases. The author discusses also the inner electromotive force developed in electrical discharges. He also takes issue with Professor J. J. Thomson theory of stratification.—*Ann. der Physik*, pp. 89–112, No. 5, 1901. J. T.

12. *A Treatise on Electro-Magnetic Phenomena and on the Compass and its Deviations aboard Ship; mathematical, theoretical, and practical;* by Commander T. A. LYONS, U. S. Navy. Volume I, pp. xv and 556. New York, 1901 (John Wiley & Sons). — The author has undertaken the preparation of an exhaustive treatise upon the use of the magnetic needle on shipboard. This is a subject of the greatest importance as well as of very general interest, and one which it is difficult to find adequately treated in any single volume. We have before us the discussion of the physical subjects which form the basis of the practical discussion which is to follow. In order to bring out clearly the nature of the periodic changes that take place in the earth's magnetism, as well as the complex relations of magnetism and electricity in general to the ether, the author has begun with the foundation subjects and treats them in a familiar and popular way, so as to be intelligible to one whose studies have not been definitely along this line. For example, he treats of wave motion generally, from the sound wave to those of Hertz, and in the part of the volume following, discusses not only the magnetism of the earth, and the methods of determining magnetic elements, but also the phenomena of magnets and magnetic fields in general. The second volume, which is to contain the discussion proper, will be awaited with interest.

II. GEOLOGY AND NATURAL HISTORY.

1. *The Eocene Deposits of Maryland*, by WILLIAM BULLOCK CLARK and GEORGE CURTIS MARTIN, pp. 1–92; and *Systematic Paleontology*, by Messrs. CASE, EASTMAN, ULRICH, CLARK, MARTIN, VAUGHAN, BAGG, HOLLICK. Pp. 93–331, Plates L–LXIV. *Mary-*

land Geological Survey. Baltimore, 1901.—The authors of the first paper have drawn the distinction between stratigraphic and paleontologic units; but as they state, "the former are designated as formations and members, the latter as stages and substages. As their limits are the same the same name is employed for each." Names are given in the following table:

Group.	Formations or stages.	Members or substages.
Pamunkey.	Nanjemoy	Woodstock
		Potapaco
	Aquia.	Paspotansa
		Piscataway.

The several members or substages are still further divided into zones from which the faunules are obtained which are listed.

The zones are apparently discriminated on a lithologic basis and grouped together on a paleontologic basis into members. The details are carefully worked out and the results are well arranged. The only criticism the writer would suggest is that the discrimination between formation and fauna is not carried far enough to exhibit the full value of the fossils in correlation.

If the combination of species, called substages, is supposed to be restricted to the formational divisions, called members, then the paleontological statistics may serve to identify the members; but if the species instead of stopping their existence migrated at the end of each member, the true value of the species in correlation is not reached by applying the same name to the formational members and to the faunal substages.

The paleontological part has been (as it should be) assigned to specialists. The whole fully keeps up the reputation these reports have held from the beginning of the new administration.

H. S. W.

2. *Annual Report of the Geological Survey of Arkansas for 1892.* Vol. V. The Zinc and Lead Region of North Arkansas; by JOHN C. BRANNER, State Geologist. Pp. 1–395, plates 1–38, and figs. 1–92. Little Rock, 1901.—An appropriation made by the Arkansas legislature in 1899 provided for the publication of this volume, the investigation for which was completed before the official termination of the Survey in 1893.

The chief part of the volume is concerning the zinc and lead deposits of northern Arkansas. These ores were originally deposited in sedimentary beds of the Ordovician age, and by infiltrating waters were carried through fissures to form secondary deposits in cavities in rocks of later age.

The Paleozoic faunas of northern Arkansas, Chapter vii, pp. 268–362, by Henry S. Williams, is here published for the first time. The report was prepared during the progress of the Survey, its detention having been caused by lack of appropriations for its publication. The report contains a classification of the Paleozoic formations of the northern part of the State, with lists of the contained faunas, and discussion of several complex strati-

graphic problems, one of which concerns the geological horizon of the manganese deposits. H. S. W.

3. *Summary Report on the operations of the Geological Survey of Canada for the year 1900;* by GEORGE M. DAWSON, Deputy and Director. Pp. 1–203. Ottawa, 1901.—This last report of the late director, issued after his death, exhibits the customary energy and progress of the Survey in developing the geological resources of the Dominion.

The commercial value of mica and molybdenite has led to their special examination by experts. The mica (phlogopite) of Quebec and Ontario is of special value for electrical purposes; but the most satisfactory market is shown to be the United States and not Great Britain. Molybdenite samples subjected to critical test show that cobbing and hand-picking may be carried on with the ordinary ores profitably, but when the ore is of low grade, rolling, screening and jigging are not economically successful.

Salt is reported from the "Medina formation" in a well near St. Grégoire, Beauce Co., Quebec.

The Crows Nest coal field is estimated to contain 22 billion tons of possibly workable coal. The coal is of Cretaceous age, and has excellent coking qualities with small percentage of ash. A similar Cretaceous coal area has been discovered between the 55th and 57th parallels of latitude in British Columbia; and anthracite has been found in the region of the head waters of the Skeena and Stikine Rivers. The fuel near Forty Mile Creek on the Yukon is Tertiary lignite, but samples of anthracite are reported from a locality west of Lake Marsh.

Study of the formations of the Brockville map-sheet (Ontario) has revealed the fact that fossils referred to in earlier reports as obtained from beds of Potsdam age, are found in what are known as transition beds between the sandstone and the limestone. The best specimens were obtained "from weathered surfaces of a siliceous limestone which represents the base of the Calciferous formation."

Investigations in the Cambro-Silurian slate region of York and Carleton Counties, New Brunswick, have developed the fact that the fossiliferous Silurian rocks overlie discordantly the Cambro-Silurian slates; and Cambrian fossils have been found in black shales near Benton, Carlton Co., belonging apparently to the lower series. Nevertheless a satisfactory solution of the difficult stratigraphical problem is not yet reached.

The Arisaig formations have received special study with the result of their reduction to four divisions, to which the names Stonehouse, Moydart, McAdam and Arisaig formations are applied. H. S. W.

4. *A revision of the genera and species of Canadian Paleozoic Corals—the Madreporaria aporosa and the Madreporaria rugosa;* by LAWRENCE M. LAMBE. *Geological Survey of Canada.* Contributions to Canadian Paleontology, Vol. IV, Part II, pp. 97–197,

plates VI–XVIII. Ottawa, 1901.—The paleontologic and literary part of this report leave nothing to be desired, and the drawings are admirable portrayals of the characteristics of the species drawn by the author and thus having all the value of scientific definition. A few notes regarding correlation are of importance. It is suggested by Dr. Whiteaves that "American stringocephalus zone" be applied to the Manitoba horizon to avoid confusion with the European zone of that genus (p. 104). Attention is called (p. 124) to Billings' identification of the Gaspé limestone, No. 8 of Indian Cove, Gaspé, "as nearly of the age of the Oriskany sandstone." The application of "Lower Helderberg" to the fauna of L'Anse à la Barbe, Baie des Chaleurs, Que., is commented on; the opinion of Dr. Whiteaves cited that the limestone seems to be most nearly equivalent to the Guelph formation of Ontario, Ohio and Wisconsin (see foot-note, p. 129), and the remark is made that the term Lower Helderberg has been used in part I of this volume, "in a sense as comprehensive as that evidently implied by the term in the 'Geology of Canada.'" This comprehensive use of the term should be considered in reading the review of the writer on the first volume. (See this Journal, ix, p. 155, 1900.) H. S. W.

5. *The structural relations of the Amygdaloidal Melaphyre in Brookline, Newton and Brighton, Mass.;* by HENRY T. BURR. Bull. Mus. Comp. Zool. at Harvard College, Vol. 38, Geol. series, Vol. V, No. 2.—This paper once more brings to our notice the dispute regarding the structural relations of the melaphyres of the Boston Basin and the associated sedimentary rocks. Mr. Burr concludes, from observations made in the field, that, for the area studied, the beds of melaphyre are strictly intrusive in character; and in so doing he takes very decided and pointed exception to the views of Prof. W. O. Crosby, who, as is well known, considers the main beds, at least, to be unquestionably contemporaneous flows. The facts upon which Mr. Burr bases his main conclusions are: "1. The conglomerate associated with the melaphyre contains no fragments of it. 2. The contacts, wherever found, are igneous in character. 3. The melaphyre is seen in contact with sediments varying from the coarsest of the conglomerate to the finest of the slate. 4. The distribution of the melaphyre shows it to be discordant with the structure of the sediments under any interpretation of the latter that has been offered." In the May number of the American Geologist, Prof. Crosby has taken occasion to call into question some of Mr. Burr's statements and conclusions and to present again the arguments in favor of the contemporaneous character of the melaphyre. He calls attention to the fact that, contrary to Mr. Burr's statement, fragments of melaphyre *are* found in the overlying conglomerate; and shows, we think, very clearly, that, so far as the character of the contacts and the other relations to the associated sedimentaries are concerned, the melaphyres are as well considered contemporaneous as intrusive sheets. He points out that the main melaphyre

beds have all the characteristics of lava flows, and raises the very pertinent question why, if, as is claimed, the melaphyre and trap dikes of the region are petrographically hardly distinguishable rocks, we find a huge dike of melaphyre amygdaloidal and scoriaceous in texture, while a three-foot dike of trap is a dense, holocrystalline rock. Attention is also called to the significant presence of well defined beds of tuff, a fact entirely overlooked by Mr. Burr. In the light of these and other facts brought out by Prof. Crosby it would seem, even to the casual reader, that the weight of evidence is overwhelmingly in favor of a contemporaneous origin and that Mr. Burr's paper is thus the unintentional cause of strengthening an exactly opposite conclusion from the one given in the paper itself.

In view of the fact that Prof. Crosby had, some twenty years ago, fully described the "new interpretation" of the structural relations of the Chestnut Hill slates to the northern conglomerate, now presented by Mr. Burr, the word "new" seems, to say the least, rather superfluous. C. H. W.

6. *Sul Periodo di forte Attivita esplosiva offerto nei mesi Aprile-Maggio* 1900 *dal Vesuvio;* par R. V. MATTEUCCI. Boll della Soc. Sism. Ital., Vol. vi, 8°, 110 pp., 6 pl., 1901.—This volume gives a detailed account of the phenomena and products attending the period of explosive activity of Vesuvius at the time mentioned. The author begins with a general description of the phenomena of the explosions, discusses their frequency and describes their effects on the crater, etc. He then discusses the material ejected, the powder and sands, the lapilli, scoria, bombs and solid blocks, each of which is made the object of particular study. An immense quantity of these blocks were ejected, a photograph being given of one containing twelve cubic meters of material. Chemical determinations show that the ejected matter was somewhat lower in silica than previous effusions of the volcano. Some calculations of the force involved in projecting the large block mentioned above are also given, showing that it reached an altitude of about 300 meters. The work closes with a discussion of volcanic explosions, both former ones of Vesuvius and of other volcanoes as well.

The plates are very beautiful and interesting heliotype reproductions of instantaneous photographs, showing the form and development of the smoke cloud from the great vapor puffs in different stages and the swarm of projected blocks in mid-air. The work as a whole is an excellent contribution to the study of volcanic outbreaks in general and to the history of Vesuvius in particular. L. V. P.

7. *Der Vulcan Etinde in Kamerun und seine Gesteine;* von E. ESCH. Sitzber. d. k. preuss. Akad. d. Wiss. zu Berlin, phys. mat. Classe 1901, XII and XVIII, pp. 41, figs. 22.—Etinde is one of the smaller volcanos of the Cameroon Mts., a volcanic group covering some 150 square kilometers, close on the coast of western Central Africa, and whose highest peak attains an altitude of

13,700 feet. The volcano is greatly eroded and is one of the oldest of the group. Its age cannot be exactly told, but the tuffs and ashes of the group cover sediments of Upper Cretaceous age and contain plant remains representing the present flora.

The chief interest lies in the igneous rocks which form the lavas of the mountain. They are of highly alkaline types, and among them are represented leucitite with phenocrysts of nephelite, hauynite and augite, occasional pyrite and perofskite in a groundmass of leucite, nephelite and augite, with some apatite

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	P_2O_5	TiO_2	SO_3	Cl	CO_2	
1	46·48	19·00	4·74	2·30	tr.	2·49	4·35	8·46	6·78	3·31	·15	1·22	·19	·08	·36	= 99·91
2	40·10	15·27	10·13	1·85	·08	4·59	12·08	4·78	3·34	2·93	·87	3·64	—	—	·23	= 99·89
3	39·97	17·30	7·41	3·05	·09	3·82	10·53	5·14	3·56	4·11	·84	3·34	·06	·14	·33	= 99·89
4	39·30	13·66	7·42	4·45	·08	4·46	11·37	5·78	1·44	4·53	·85	3·62	2.17	·48	·15	= 99·76
5	39·37	16·50	2·28	7·97	·06	4·48	10·22	4·73	3·38	4·77	·13	3·31	2·14	·09	·64	= 100·07
6	38·39	12·64	7·40	6·15	·02	6·46	14·17	4·35	2·44	1·62	1·16	4·44	·47	·37	·23	= 100·31
7	40·15	17·32	7·25	4·00	·08	4·43	11·78	5·99	3.78	1·18	·71	3·21	—	—	·15	= 100·38

1, Leucitite; 2, Leucite nephelinite; 3, Leucite nephelinite, including ZrO_2=·20; 4, Hauynophyre; 5, Hauynophyre; 6, Nephelinite, of a special variety; 7, Normal nephelinite, including ZrO_2=·35. All analyzed by Dr. Max Dittrich.

and perofskite. Leucite composes about one-half the rock. Leucite nephelinite also occurs, composed of augite, apatite and ores in a groundmass of augite, leucite and nephelite, the latter predominating. Hauynophyres occur containing phenocrysts of hauynite, augite and ore grains in a groundmass much like those just mentioned. A nephelinite of a special variety in which the nephelite in the groundmass is not fully individualized is also described. Phenocrysts of augite, hauynite, apatite and titanite lie in a clear colorless base with microlites of augites and ore grains. The colorless base is held to be partly individualized nephelite. Nephelinites of normal type are also described and the twinning and optical properties of the larger individuals is made a special study. The accompanying table of analyses will be of interest to petrographers. L. V. P.

8. *Söndre Helgeland* af J. H. L. Vogt. (Norges Geologiske Undersögelse No. 29, 1900, Kristiania, 8°, 180 pp., 1 map, 21 figs.) —This work is devoted to an account of the geology of Helgeland, the southern part of the district of Nordland in northern Norway. With the exception of a small area of Archean the region is composed of metamorphic schists and limestones, probably of Cambrian-Silurian age. The author divides the metamorphosed sediments into mica schist, marble, and a later gneiss. In addition there are extensive areas of eruptive rocks consisting mainly of soda granite and gabbro. Sometimes these are strongly stretched and squeezed and are then held to have been injected previous to the final dynamic foldings which gave birth to the mountain chains; sometimes they are in normal condition and are then held to be of contemporaneous or later age.

A careful study of the morphology of the region is given by the author, the quaternary geology by him and REKSTAD, and the work is concluded with an account of the silver ore veins of Svenningdalen.

A résumé in German is given at the end. The work throughout is full of the suggestiveness in ideas and thoroughness in details that are characteristic of the author. L. V. P.

9. *Classification of Igneous Rocks.*—E. VON FEDEROV, in an article published in the Journal of the Mineralogical Society of St. Petersburg in 1900, page 395, gives a method for the classification of igneous rocks in which he endeavors to show that it is possible to divide all of the eruptive rocks into types and classes by assigning to them simple symbols like those used in crystallography.

In considering the general chemical composition of rocks in the order of the oxides, 1, R_2O; 2, RO; 3, R_2O_3; 4, RO_2, it becomes evident that all of the ordinary rock-making minerals may be expressed by symbols of four numbers. Thus, quartz (0001), corundum, hematite, etc. (0010), spinel, magnetite (0120), olivine (0201), diopside and actinolite (0101), garnet (0323), biotite (1223), phlogopite (1313), anorthite (0122), orthoclase and albite (1013), leucite and aegirite (1012), nephelite (8089).

The reckoning of the different compositions is based on a regular tetrahedron whose summits are the points (1000), (0100), (0010), (0001); the center of the faces are the points (0111), (1011), (1101), and (1110); the center of the edges (1100), (1010), (1001), (0110), (0101), (0011), whilst the center of the tetrahedron is (1111).

Using these points the tetrahedron can be divided into 24 sphenoids, to whose centers there correspond 24 typical compositions. Of these fundamental types of chemical composition only four are represented, those having the symbols (1423), No. I, (1324) No. II, (1234) No. III, and (2134) No. IV. No. 1 is represented by the *periodotites*, No. 2 by rocks of the *gabbro* group, No. 3 by rocks of the *diorite* and *diabase* groups, and No. 4 by rocks of the *granite* and *syenite* groups.

The division of the types into classes is done by dividing the sphenoids into 24 sphenoids of the third order. By the aid of the principles of zonal crystallography the author explains the process to be followed to obtain the chemical composition when the indices corresponding to the third order are given, and how to determine if this composition is a *typical* one (represented by an interior point of the sphenoid), one *intermediate* between the classes, one of *transition* between the great types, or an *extreme* rock.

The author shows how these may be determined by graphic methods and makes a number of applications of his system. The main body of the text is in Russian, but a short résumé in French permits the salient features of the article to be understood by those who are not versed in that language. L. V. P.

10. *Boletìn del Instituto Geologico de Mexico, Num.* 13, *Las Rhyolitas de Mexico.* Primera parte, por EZEQUIEL ORDEÑEZ, Mexico, 1900, 4°, 75 pp., 1 map.—This bulletin is the first of a series to be issued on the eruptive rocks of Mexico. The aim of the series is to make known the great number of varieties of rocks, their geographical distribution and field relations, their physiographic features, and economic importance as building material and soil. It is also expected to bring about uniformity in the petrographic nomenclature of Mexico. The first part of the bulletin is devoted to historical notes, principal subdivisions of the rhyolite family, macroscopic characters of the rhyolites and geographic distribution of the rhyolites in Mexico. The second and greater part is devoted to the description of various localities under the following four heads: (1) The "Bufas," (2) The Navajas, (3) Other regions of the Central Plateau, (4) The western Sierra Madre. The term "bufa," for many years applied by the miners in the region about Guanajuato and Zacatecas to curiously shaped masses of rock crowning the summits of prominent points, is adopted by the writer to designate these isolated erosion remnants of rock of a rhyolitic nature. The bulletin closes with a chapter upon the age of the rhyolites and a résumé in French.

Points of general interest are: the great distribution of the rhyolites, surpassed only by the andesites, in a belt reaching southward from the northern boundary of the country through the western Sierra Madre into the Central Plateau to the vicinity of the city of Mexico; the greater part of them were erupted from the end of the Miocene to the middle of the Pliocene. The succession of Tertiary eruptives, based on the evidence thus far presented, is: (1) Granites-Granulites, (2) Diorites-Diabases, (3) Andesites-Dacites, (4) Rhyolites, (5) Dacites-Andesites, (6) Basalts-Basaltic andesites. There are two modes of occurrence, namely, in the western Sierra Madre from fissures parallel to lines of relief, and in the Central Plateau from local vents. The intimate connection between the geologic structure and the eruptive rocks of the western United States and the mountains of Mexico is also of interest. H. H. R.

11. *Brief notices of some recently described minerals.*—CONCHITE. This name has been given by Agnes Kelly to the calcium carbonate forming a considerable part (often associated with calcite) of the calcareous secretions of molluscan shells. This form, unlike aragonite to which it has been referred (G. Rose), is uniaxial and optically negative, as is calcite, and yet it differs from the latter mineral in some other characters. The most conspicuous difference is in the specific gravity, which is 2·87 for conchite, and 2·71 for calcite. It shows no twinning and has higher refractive indices; thus ϵ is 1·524 for conchite and 1·486 for calcite. Conchite is an unstable compound changing into calcite at 300° to 310°. Various natural incrustations (Karlsbad, Yellowstone, etc.) were found to consist of conchite; here also belongs the Flos Ferri.—*Min. Mag.*, xii, 363.

SELIGMANNITE. A new species described by Baumhauer from the dolomite of the Binnenthal in Switzerland; it is named after the mineralogist, G. Seligmann of Coblenz. The material was too scanty to allow of analysis, but its close identity with bournonite in complex crystalline form and the similarity in color and luster and brittleness to sartorite (scleroclase), have led the author to the conclusion that it is a lead sulpharsenite isomorphous with the former species.—*Ber. Ak. Berlin*, p. 110, 1991.

HUSSAKITE. A mineral occurring in tetragonal crystals and in crystal fragments at Dattas near Diamantina, Minas Geraes, Brazil. The form is identical with that of xenotime, but analysis showed the presence of 6 p. c. SO_3. The results obtained are as follows:

	SO_3	P_2O_5	$(Y, Er, Gd)_2O_3$	Fe_2O_3
	6·13	33·51	60·24	0·20=100·08.

The hardness is 5; sp. gravity 4·587; the color, yellowish white to honey-yellow and brown. The authors, Kraus and Reitinger, suggest that the xenotime hitherto analyzed may have been altered from hussakite, the SO_3 having been removed; they regard Gorceix's earlier analysis of the Brazilian mineral, which showed no SO_3, as incorrect.—*Zeitschr. Kryst.*, xxxiv, 268.

CERULÉITE. An arsenate of aluminum and copper from the gold mines of Huanaco, Chili, described by H. Dufet. It occurs in clay-like masses of a turquois-blue color; these masses consist of very minute crystals. The specific gravity is 2·803. An analysis gave the following results:

As_2O_5 34·56 Al_2O_3 31·26 CuO 11·80 H_2O 22·32=99·94.

This corresponds approximately to the formula $CuO \cdot 2Al_2O_3 \cdot As_2O_5 + 8H_2O$.—*Bull. Soc. Min.*, xxiii, 147, 1900.

SULVANITE. A sulpho-vanadate of copper described by G. Goyder from Burra, South Australia. It occurs in masses with a metallic luster and bronze-yellow color; hardness 3·5; specific gravity 4·0. The calculated formula is $3Cu_2S \cdot V_2S_5$, deduced from two analyses, one of which is as follows: S 32·54 V 12·53 Cu 47·98 SiO_2 4·97 Fe_2O_3 0·42. The silica and iron are due to impurities.—*J. Chem. Soc.*. Sept. 1900, p. 1094.

TERMIERITE, LASSALLITE. Two silicates of aluminum described by G. Friedel as occurring with kaolinite and barite at the antimony deposits of Miramont on the borders of Cantal and Haute-Loire, France. The composition of *termierite* is regarded as expressed essentially by the formula $Al_2O_3 \cdot 6SiO_2 + 18H_2O$; an an analysis gave: SiO_2 78·29, Al_2O_3 15·00, Fe_2O_3(FeO pt. ?) 4·85, CaO 1·77, MgO 0·47=100·38. It occurs in small masses of a gray color and conchoidal fracture.

Lassallite occurs in white fibers resembling asbestus. An analysis of dried material gave: SiO_2 69·27, Al_2O_3 19·42, Fe_2O_3 0·84, MgO 10·01, CaO 1·30=100·84; H_2O 14·22. The calculated formula is $3MgO \cdot 2Al_2O_3 \cdot 12SiO_2 + 8H_2O$.—*Bull. Soc. Min.*, xxiv, 4, 1901.

TORRENSITE, VIELLAURITE. Supposed new minerals consisting of the carbonate and silicate of manganese described by Lienau, the former substance occurring in gray to brown masses at the Torrens mine, Haute Pyrénées. It is shown by Lacroix to be a mixture of rhodonite and rhodochrosite. The same author also shows that the *viellaurite* is a mixture of rhodochrosite with a silicate, probably tephroite, and small quantities of alabandite.—*Bull. Soc. Min.*, xxiii, 251.

VIOLAITE. A strongly pleochroic pyroxene (with green and orange-yellow colors) which forms an essential constituent of the rock from the Kedabek copper mines called by Federow *Kedabekite*. An analysis gave: SiO_2 48·26, Al_2O_3 3·84, Fe_2O_3 1·15, FeO 15·77, MgO 8·09, CaO 22·61, Na_2O 0·28=100.

12. *On Iron Meteorites.*—Prof. E. COHEN gives in a recent paper (Sitzb. Akad. Wiss. zu Berlin, Dec. 13, 1900) a summary of the results of his recent thorough and detailed chemical and structural study of the iron meteorites which lack cubic or octahedral structure. These include Brezina's group of Ataxites and his Hammond, Capeisen and Chesterville groups. The following were found by Cohen to be pseudo-meteorites: Nauheim, Newstead, Walker Co., Scriba, Hemalga, Saint Augustine's Bay, Long Creek, Virginia, and Minas Geraes. Tocavita, Salt River and Ballinoo, Cohen considers to be octahedrites with finest lamellæ; Santa Rosa a granular aggregate of octahedral individuals and Bingera a granular aggregate of cubic individuals. The remainder are grouped by Cohen under the term "*Körnige bis dichte Eisen.*" These are subdivided into (a) granular to compact, streaked (*schlierenführende*) irons and (b) granular to compact irons without streaks (*schlierenfreie*). The latter are considered the only true ataxites.

Group *a* is subdivided into (α) irons with octahedral streaks (*schlieren*) and includes Cacaria and Hammond, and (β) irons with cubic streaks (*schlieren*). This latter group includes Cape of Good Hope, Kokomo, Iquique, Shingle Springs, and Sierra de la Ternera.

Group *b*, or the true ataxites, is divided into two subgroups. The meteorites of the first subgroup are rich in nickel, the content of Ni + Co being 17–20 per cent. Those of the second subgroup are poor in nickel, the content of Ni + Co being 6–7 per cent. Under the first (Morradal group) Cohen classes Smithland, Babb's Mill, Deep Springs, Botetourt, Dehesa, Linnville Mountain and Morradal. The second is subdivided into the Siratik group, under which are included Siratik, Campo del Cielo, Locust Grove, Mesquital and Cincinnati, and the Nedagolla group, which comprises Rasgata, Chesterville, the Wöhler iron, Nedagolla, Primitiva and Forsyth Co. Tucson is considered intermediate in character, the content of nickel being about 9 per cent, while forsterite is present as an accessory constituent. Illinois Gulch is classed with the Nedagolla group although the percentage of nickel is high (12 per cent).

The author finds structure throughout dependent upon the chemical composition, thus confirming the conclusions which he had previously formed from studies of the octahedral and cubic irons. O. C. F.

13. *Studien über den Milchsaft und Schleimsaft der Pflanzen ;* by HANS MOLISCH, Director of the Institute for Plant Physiology at the German University in Prague. Pp. viii + 111, with 33 text-figures. Jena, 1900 (Gustav Fischer).—Previous writers on the milk-tubes of plants have studied more especially the development of the tubes and the structure of their walls. In the present paper, Professor Molisch gives a full account of the milky juice inside the tubes, describing its microscopic structure and chemical composition. According to the older writers, the tubes are wholly devoid of protoplasmic contents. According to the more recent work of Berthold, the whole milky juice is to be looked upon as a modified protoplasm. The author, however, finds neither view correct, but distinguishes in the intact tubes a layer of cytoplasm, which lines the wall and which has imbedded in it numerous nuclei, leucoplasts and vacuoles, and considers the space enclosed by this layer as a sap-cavity filled with a milky cell-sap. He confirms thereby the work of E. Schmidt, who found both cytoplasm and nuclei even in old tubes. In the milky juice which exudes from cut surfaces, the protoplasmic elements become so thoroughly mixed with the cell-sap that they cannot be distinguished. In addition to nuclei of the ordinary type, the author describes a peculiar variety of nucleus to which he has given the name "Blasenkern." In this the nuclear membrane is separated from the nuclear substance to a greater or less extent by a space filled with liquid. Since it is sometimes possible to convert ordinary nuclei into "Blasenkerne" by the addition of water, it would seem probable that the latter were abnormal, but this view is not held by the author. The leucoplasts usually give rise to starch-grains, but, in some cases, to solid proteids or to oil-drops, both of which may also occur in the vacuoles. Other organic substances sometimes found in the milky juice are caoutchouc, resins, tannins, soluble proteids and carbohydrates and the recently described leptomin of Raciborski. The juice of the Papaveraceæ contains also various alkaloids. Whether these substances occur in the cytoplasmic sheath or in the sap-cavity could not always be determined. The slime-tubes, which are found in certain monocotyledonous families, show a structure very similar to that of the milk-tubes, but the sap-cavity contains slime, which is only occasionally milky. The nuclei are very variable in shape and are sometimes drawn out into long hair-like structures. The slime-tubes contain many of the substances found in milk-tubes. In addition to these the author describes as new an organic body to which he gives the name "luteofilin." Little could be determined with regard to its chemical composition. The luteofilin crystallizes out of the slime in the form of sphærites, which show a distinct concentric lamellation. They are soluble in water but

insoluble in absolute alcohol, ether and benzole. Upon the addition of 20 per cent. potash solution, the luteofilin appears in the form of long and slender thread-like masses of a bright yellow color, from which the substance receives its name. Regarding the functions of the milk- and slime-tubes, the author does not express himself very fully, but reserves this subject for a future paper. A. W. E.

14. *A Remarkable Instance of the Death of Fishes, at Bermuda, in 1901;* by A. E. VERRILL.—During the month of February and the first part of March of this year the weather at Bermuda was unusually cold and wet. The temperature fell, at one time, as low as 45° F. The continued low temperature was sufficient to cool the sea water beyond the limit of endurance for many of the tropical fishes found there, so that vast numbers died and were washed ashore, especially during the first week in March, all along the coast, but more abundantly around the shores of Hamilton Harbor and the adjacent islands. The stench from their decomposition became so great that the local government was obliged to aid in their removal early in March.

Numerous species of fishes were thus affected as well as certain crabs, corals, etc. The fishes that died in the largest quantities were two of the commoner shallow-water species, viz., the hamlet grouper and the squirrel-fish. Later in the season these and other fishes that previously have always been common were found to be scarce and difficult to obtain. In fact, most of the ordinary market fishes were much scarcer and harder to obtain than ever before. Among numerous other fishes seen dead on the shores were parrot-fishes of several kinds, small rock-fishes, hog-fishes, white grunts, large porcupine-fishes, trunk-fishes, cow-fishes, angel-fishes, rainbow-flounders, etc. Also large specimens of *Octopus*.

Those fishes that habitually live in deep water, among the outer reefs, such as the red snapper, large rock fishes, amber fishes, etc., seem not to have been thus affected. Some of the smaller shallow water and surface fishes also seemed to have escaped, for the pilchards, hog-mouth fry, and others were still very abundant in April.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Atlas Meteorologico de la República Argentina* por ENRIQUE A. S. DELACHAUX. Primera Parte, Provincia de Buenos Aires. Buenos Aires: Comp. Sud-Americ. de Billetes de Banco.—This volume begins the publication of a general meteorological atlas of the Argentine Republic, which will appear from time to time as each province is studied in detail. Observations are taken at eighteen meteorological stations. The maps exhibit the main climatic factors of Buenos Aires. Thus it is shown that the annual temperature varies from 18° C. in the Parana Valley to 14° C. in the south central part; the temperature range for about

half the province is less than 14° C. The annual humidity reaches 82 per cent on the northeast coast line, while in the central and western part of the province it is under 70 per cent. The annual rainfall in the Parana delta is 1,000^{mm}, but there is a regular decrease to the southwest until the minimum (300^{mm}) is reached on the Rio Negro. About two-thirds of the province has an elevation less than 100^{m}. H. E. G.

2. *The British Museum Catalogues.*—The following publications have been recently issued :

A Hand-list of the Genera and Species of Birds (Nomenclator avium tum fossilium tum viventium); by R. Bowdler Sharpe, LL.D. Vol. ii, pp. xv, 312. London, 1900. Includes all species of *Psittaci* and what are known as Picarian birds; there are enumerated 454 genera and 2861 species. See also vol. viii, p. 398.

Catalogue of the Mesozoic Plants in the Department of Geology, British Museum (Natural History). The Jurassic Flora. I, The Yorkshire Coast. Pp. xii, 341, pl. i–xxi. By A. C. Seward, M.A., F.R.S., F.G.S. London, 1900.

3. *A Select Bibliography of Chemistry, 1492–1897;* by Henry Carrington Bolton. Pp. 534. Washington, 1901. (Smithsonian Miscellaneous Collections, 1253. Section viii. Academic Dissertation.)—Professor Bolton continues his laborious but most useful task of collecting chemical bibliography. The latest addition to the series is this large volume of academic dissertations, arranged alphabetically according to authors, but with a full subject-index to titles at the end (pp. 445–534).

4. *Publications of the Bureau of American Ethnology*, J. W. Powell, Director.—It is impossible here to do more than record the recent issue of the following valuable volumes :

Seventeeth Annual Report of the Director with accompanying papers. In two parts: Part I, pp. xciii, 468 ; Part II, pp. 469–752.

Eighteenth Annual Report. In two parts : Part I, pp. lvii, 518.

5. *Field Columbian Museum.* The following is a list of recent publications :

No. 45. Zoölogical Series. Vol. II. A Synopsis of the Mammals of North America and the adjacent seas; by Daniel Giraud Elliot, curator. Pp. 470. Chicago, 1901.

No. 51. Anthropological Series. Vol. II, No. 4. An Aboriginal Quartzite Quarry in Eastern Wyoming; by George A. Dorsey, curator. Pp. 235–243. Plates xxviii–xxix. Chicago, 1900.

No. 52. Report Series. Vol. I, No, 6. Annual Report of the Director to the Board of Trustees, for the year 1899–1900. Pp. 413–512. Chicago, 1900.

No. 53. Geological Series. Vol, I, No. 8. Observations on Indiana Caves; by Oliver Cummings Farrington. Pp. 247–266. Chicago, 1901.

No. 54. Zoölogical Series. Vol. III, No. 3. List of Mammals obtained by Thaddeus Surber, Collector for the Museum in the Provinces of New Brunswick and Quebec, Canada; by D. G. Elliot, curator. Pp. 15–29. Chicago, 1901.

6. *Scientia.* L'Evolution du Pigment; per G. Bohn. Pp. 94. —This is the eleventh volume of this valuable series. Paris, 1901 (Georges Carré et C. Naud).

7. *Zoologisches Addressbuch:* Namen und Addressen der lebenden Zoologen, Anatomen. Physiologen und Zoopaleontologen, sowie der künstlerischen und technischen Hülfskräfte, herausgegeben im Auftrage der Deutschen Zoologischen Gesellschaft von R. Friedländer und Sohn. Teil II, pp. viii, 517. Berlin, 1901.—This second part of the International Zoologists' Directory (see this Journal, i, 77, 1896) includes announcements of deaths, changes of address, corrections and additions, dating from September, 1895: it thus completes this valuable work up to 1901.

8. *Publications of the Earthquake Investigation Committee in Foreign Languages, Nos. 5 and 6.*—The recent contributions to this important series, repeatedly noticed in these pages, contain the results of horizontal pendulum observations of earthquakes from July, 1898, to December, 1899, in Tokyo, by Dr. F. Omori.

9. *Publications of the United States Naval Observatory.* Second Series, Vol. I, pp. cvii, 402. Washington, 1901.—The second series of the U. S. Naval Observatory publications is commenced with the present volume. With it the plan of publication will be different from that which has been in force hitherto, since, in the place of annual volumes, it is proposed to issue volumes at suitable intervals depending upon the kind and amount of material available. We have here all the transit circle observations of the sun, moon, planets, and miscellaneous stars made from 1894 to 1899, except those of the zone $-13^\circ\ 50'$ to $-18^\circ\ 10'$. The observations were made under the direction of Prof. W. Harkness until his retirement as Director in December, 1899. Prof. A. N. Skinner was in charge of the transit circle during this period; the Directorship of the Observatory is now under the charge of Prof. S. J. Brown.

University of Tennessee Record. The April number of the Tennessee Record (vol. iv) contains a series of scientific papers; among these may be mentioned one by A. C. Lanier on technical education in the South; another by E. F. Kern on the electric current in chemical analysis; by W. W. Carson on the polar planimeter; by W. M. Fulton on automatic record of water stages in the upper Tennessee river.

The New York University Bulletin of the Medical Sciences. A publication devoted to the scientific work in the Carnegie Laboratory and other departments of the Medical College. Conducted by the New York University Medical Society of the University and Bellevue Hospital Medical College. Vol. I, No. 1, January, 1901. Pp. 56. Lancaster, Pa. and New York (The Macmillan Co.).

School Science. A Journal of Science Teaching in Secondary Schools; edited by C. E. Linebarger with the aid of twelve associate editors. The first number (pp. 1–51) of this new periodical is dated March, 1901. It will be published monthly, September to May inclusive, by School Science, Unity Building, Chicago; price $2,00 per year.

Memoirs of the National Academy of Sciences. Volume VIII. Fifth Memoir. Anatomy of Nautilius Pompilius; by Lawrence Edmonds Griffin. Pp. 197. Plates I–XVII. Washington, 1898.

Mountain Structure and its Origin; by JAMES GEIKIE. International Monthly, January and February, 1901.

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